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ELECTRIC TRACTION.

THE paper on "Electric Traction, and its financial aspect," read by W. Stephen Sellon before the Society of Engineers, on the 7th inst., cannot be said to contain much that has not already been published, but it had the most useful effect of exciting a lively discussion, and for this one should feel grateful. It is seldom indeed that the Society of Engineers adjourns the discussion of any paper, therefore in this case it speaks volumes for the interest taken by engineers in general, in the problem of electric traction. The author divided his subject under the following comprehensive headings, viz.: The accumulator system; the overhead system; the conduit system; and the commercial question. Concerning the accumulator system, Mr. Sellon went to the trouble of telling his audience that it had proved a failure in Brussels and elsewhere, and that on the Birmingham Central Tramway its working costs were slightly above the cost of horse traction. The overhead system, which has found such marvellous development in the United States, received due consideration, in so far as statistics regarding the number of cars in use are concerned, and comparative statements on the cost of electric traction and horse traction were given. On the West End Road, Boston, for instance, the operating expenses by horse traction were in June last year 66·7 per cent. of the gross earnings, while those of electric traction were 47·7 per cent. The author laid great stress upon the interesting fact that the electric cars have a much greater earning capacity than the horse cars, and there are two reasons for this: 1st, economy of working, and, second, increase of traffic, due to what may be called "public satisfaction." The cost of operating cars on the West End lines in April last year was, with horses, 12·65 pence per car mile, of which 5·38 pence fell to the item of "motive power," whilst with the electric lines the gross expenses were 10·77 pence per car mile, out of which 3·79 pence fall into the item of haulage by electric motors. In another example (the town is not mentioned) six miles of tramway were worked by horses up to September, 1889, making an annual mileage of 87,708 with five cars earning £1,500 net. The following year the same tramway was worked electrically with the same number of cars, when 117,450 car miles were run, and the earning capacity of the road was increased 37½ per cent. over that of horse traction, while the operating expenses were reduced from 8·4 pence to 6·9 pence per car mile.

Such figures are useful in the sense that they convey the general idea that electric traction is more economical than horse-traction, but what engineers of the present day are looking for are detailed items. What proportion of the total expenses go for fuel, water, oil, and wages at the generating station. How much is spent on repairs and renewals of all the different parts forming a complete system. What is the power used at the generating station for a given line and

traffic. Upon these and other important questions of detail the author had not a word to say.

Where the overhead system is objected to, tramway companies must turn their attention to the conduit system, of which there are two types, viz., the closed conduit and the open conduit. From a commercial as well as from a technical point of view, says Mr. Sellon, the closed conduit system, as at present before us, is open to three grave objections. "Firstly, the necessity of putting short lengths of surface rail temporarily into circuit by means of some electro-magnetic device, appears to be too complicated to be reliable in working. Secondly, the practical impossibility of making such a system thoroughly insulated in a street subject to heavy traffic; and, thirdly, supposing these two difficulties to be overcome, the impossibility of ensuring a proper contact when the road is covered with water, dirt or snow, and the impracticability of laying short lengths of rails with sufficient rigidity in a street where there is a heavy traffic." Several of the advocates of closed conduit systems were present at the meeting, but they had no opportunity of replying to these attacks upon their pet schemes. Probably, at the next meeting, we shall hear the views of Messrs. Wynne, Gordon and Lineff upon this section of a great subject.

The only example of the open conduit system in England is the Blackpool tramway. Mr. Sellon acknowledged that, as a first attempt, all credit was due to Mr. Holroyd Smith, for the way in which this installation was put down, but he also said that there were many features in it which do not warrant it being called *the* conduit system of the future. After enumerating the many alleged faults both in the mechanical and electrical applications to the conduit system at Blackpool, the author described the Waller-Manville system, which he considers superior to any other. "The insulation is practically perfect. The conductor being a flexible cable, it requires fewer supports than in the case of a rigid conductor, and these supports are situated in chambers covered with hatches similar to, though smaller than, those in use on cable tramways. The conductor being flexible, can be taken out or replaced through the slot, without interfering with the conduit. Large insulators can be used, owing to the available space in the hatchways; whereas, in the rigid conductors, the supports are necessary in the conduit, and liable to become covered with mud." Considering the numerous carefully worked out systems, it is to be regretted that no opportunities are offered in the United Kingdom for them to be applied in practice.

With the last division, "The Commercial Question," Mr. Sellon was rather unhappy, inasmuch as he worked out a "hypothetical case of three miles of tramway," giving the calculated prime cost and operating expenses in the event of the same being equipped by either of the following methods:—Horses, cable, overhead electric, or conduit electric. These hypothetical figures were not much appreciated, and the author would have enhanced the value of his paper by actual expenses concerning existing lines.

The following gentlemen took part in the discussion:—Messrs. Colam, Richardson, Reckenzaun, Graff-Baker, Sturgeon, and Waller. Mr. Colam advocated cable traction most eloquently, and gave interesting figures concerning that system. He regretted that the working expenses given by electric tramway companies rarely included maintenance charges which form an important item. Mr. Richardson, as chairman of the North Metropolitan Tramway Company, stated that he was satisfied with the working of the electric cars on the Barking Road, but that the extension of this or any other system of electric traction was seriously handicapped by Acts of Parliament, and especially by the fact that his company was liable to remove the electric cars within forty-eight hours of a notice given by the Board of Trade. Under such circumstances it is impossible for their shareholders or any capitalists to supply the money for the development of electric traction enterprises. Mr. Reckenzaun remarked that Mr. Colam seemed to have had the misfortune of looking at the accounts of only such electric tramway companies which did not show the cost of maintenance. In a paper which he (Mr. Reckenzaun) had recently prepared for the Institution of Electrical Engineers, he had collected a lot of useful data relating to European as well as American lines in which the cost of maintenance is fully stated, together with all the other items which make up operating expenses. He referred in particular to the figures obtained from the Blackpool line, the old Frankfort-Offenbach line, and the new Halle Tramway, all typical examples keeping accurate accounts. He regretted that Mr. Sellon adopted hypothetical figures in his paper, considering the vast amount of actual data which is now at our disposal. Mr. Graff-Baker referred to cases where electric traction was found superior to cable traction, and gave a few items entering into the cost of traction on the Roundhay Electric Tramway, and Mr. Waller dwelt upon the advantages of the open conduit system.

ELECTRICITY IN INDIA.

Up to the present, electricity has not made much progress as an illuminant in India, notwithstanding the efforts which have been put forth by English firms in sending representatives to that country. That agency moreover, has, not yet been adopted as the motive power on tramways, whilst for power purposes generally, comparatively few, if, indeed, any steps have been taken. The native daily press have recently been devoting considerable space to the subject of utilising water as the means of producing motive power, and this has been specially the case in the Madras Presidency. On the completion of the Periyar project, it is estimated that no less than 180,000 H.P. will be available at Kuruvanuth. This power, or rather that amount which would be obtained on the turbine shafts, could be used by electrical transmission at a considerable distance from the source. In Madras, alone, a fair portion of this power could be profitably employed, and it is suggested that the Government of the Presidency should appoint a commission to investigate the matter. Whether it would be worth while from a commercial point of view to go to the great expense which would be necessary to make use of a part, or the whole of the available power in question, remains to be seen, but no attempt is made to show that such an undertaking would be remunerative. The power would, according to the suggestion, be distributed within a radius of 400 miles from the generating station. This cannot now be regarded as impracticable in view of the success of the Lauffen-Frankfort transmission plant, the

proposal to transmit power from Niagara Falls to Chicago, and the present tendency towards the conduction of current at enormously high voltages. In fact, the possible pressure which may be safely used seems to be almost an open question at this moment. The main considerations are efficient insulation and the cost of putting up the wires, the latter point having been entirely neglected by the native press.

In the meantime a company is being promoted to acquire and work a concession which has been granted by the Madras Municipality to Messrs. William Hutchinson and Company for the establishment of electric tramways in Madras. The total length of the lines projected is 15½ miles, or with sidings and loops for the passing of cars, 18½ miles. As might be expected, the trolley system is to be adopted, the municipality having no objection to overhead wires. The right is reserved to the municipality to purchase the undertaking at the end of 21 years on very favourable terms to the company, namely, on the payment in gold of the amount of the gross capital account, with the addition of 25 per cent. as compensation. The company, the Madras Electric Tramways Company, proposes to apply for permission to supply the electric light, and this will doubtless be granted, especially as there are no gas works in Madras. The governor of the town, Lord Wenlock, has already approved of the scheme, which promises to be successfully put into execution. The cost of installing the line and providing the plant and buildings is expected not to exceed £5,000 per mile as compared with £20,000 per mile in the case of the Calcutta tramways.

HEAT INFLUENCE UPON THE PROPERTIES OF IRON AND STEEL WIRES.

SOME important experiments have recently been carried out by Rudeloff, who has been investigating the action of changes of temperature upon the physical properties of iron and steel wires, some of which were telegraph wires.

The method employed calls to mind the researches of Le Chatelier and others into the effects of temperature on structural iron, and the results obtained do not clash, but rather tend to substantiate what is already known of these changes; at the same time a great deal of new information is added.

Five examples of wire were examined, three being wire ropes, and the other two ordinary telegraph wires. These were of different strengths, and the results are given for each sample in the form of tables, curves being used for graphic illustration, for which consult the original paper (*vide Mitt. König. Tech. Versuchs*, 1891).

The influence of temperature was observed on :—

1. The tensile strength.
2. „ extension.
3. „ "elastic limit."
4. „ torsion test.

Certain other experiments were also carried out to determine the electrical and magnetic relations of the test specimens of wire before and after heating. The results are briefly given below :—

Exposure of the specimens to a temperature of 800° to 1,200° Centigrade had but little influence upon their electrical conductivity; such influences as could be observed appeared to be due rather to an alteration in the chemical composition of the samples than in their mechanical properties.

The temperature coefficient of the electrical conductivity and the magnetic moments of the samples decreased as the original tensile strength of the material increased after heating; the temperature coefficient showed an increase which was greater the higher the tensile strength of the original material. The magnetic moment was but slightly affected by heating, the tendency being for it to increase.

Theory of the Dissipation of Energy.

IN the current issue of the *Philosophical Magazine* there is a reprint of an article, together with an appendix, on the kinetic theory of the dissipation of energy which originally appeared in the proceedings of the Royal Society of Edinburgh for February, 1874, by Sir William Thomson. This paper is well deserving of republication, and we commend it to the notice of such of our readers who have time for, what we may term, such general reading.

Testing the Atmosphere of Mines.

A METHOD of examining the atmosphere in mines is being used now at Kolscheid near Aachen, which is noticeable from the fact that electricity is employed. Briefly, it is as follows :—A gasometer is placed in the chief ventilating shaft and is so arranged that it becomes filled in twelve hours; in this way it is possible to obtain a fair average sample of the mine air. The air thus collected is now examined by means of a Coquillon's "grisometer." Any free carbonic acid gas that may be present is absorbed by caustic soda and its percentage estimated by noting the diminution in bulk. The marsh gas, which is the dangerous element in pit atmospheres —the so-called fire damp of the miners—is now decomposed by a platinum wire heated to incandescence by means of an electric current. A further diminution in bulk takes place, and this being observed, the percentage of marsh gas present in the pit air can be calculated. We understand that this method is proving very useful, and it is satisfactory to notice that it is thoroughly reliable.

Submarine Cables in Time of War.

WRITING to the *Globe* on the 11th inst., Admiral F. A. Close, suggests that "Our telegraph cables should have a government branch cable from deep water to the nearest fort, otherwise an enterprising enemy may destroy the cables and cut us off from all communication with our fleets on foreign stations." This is all very well, but what does the Admiral consider the greatest depth at which cables could be cut by an enemy. Repairing cables in deep water is a delicate operation, requiring great experience and special appliances, but the simple cutting of them is a thing which any man-of-war, provided with a few miles of rope and a few grapnels, would have no difficulty in accomplishing, even in the greatest depth.

Coast Communication.

AT the meeting of the Association of Chambers of Commerce, last week, a resolution expressing the desirability of establishing communication with lighthouses, lightships, and coastguard stations was carried unanimously. Sir Michael Hicks-Beach spoke at some length on the matter and his statements may be taken as favourable, on the whole, to the scheme. Sir Edward Birkbeck, M.P., stated that every member of Parliament who had communicated with him in reference to this question was unanimously in favour of a

Royal Commission to inquire into the question of out-lying rock lighthouses and floating light-vessels. In regard to the general question of coast communication, they said that the matter would be dealt with by the House of Commons from a national point of view, and he had only heard of one member of the House of Commons who was antagonistic to the proposition. Every member of Parliament who had gone into the question was going to support his motion. Why should there be any question of a Royal Commission and its tedious delays? Thanks to the prominence given to the subject by the press of late, everybody admits the desirability of the proposed lines for communication, and the only question to be settled is the all-important one of "Who is to pay the piper." A meeting was also held at Ramsgate in support of the resolution, shortly to be proposed in the House of Commons on this subject by Sir Edward Birkbeck, and the following resolution was carried with enthusiasm:—"That this meeting is of opinion that electric communication between lighthouses, light-vessels, and the shore is urgently needed, and its establishment of national importance, not only commercially but above all for the speedy intimation it will afford to our brave men, ever ready to rescue those in peril at sea; other countries having successfully adopted the scheme, while, to the disgrace of England, the public have for 11 years failed to induce our Government to do so; and therefore heartily and strongly supports the resolution of Sir Edward Birkbeck, M.P., in favour of this object." The motion to be made stands as follows, and should come before the house on the 22nd inst.:—"Sir Edward Birkbeck—coast communications—to move that, with a view to the better prevention of loss of life and property in cases of vessels in distress or shipwrecked, and to give the earliest possible information to lifeboat authorities and rocket apparatus stations, in the opinion of this House, it is desirable that a complete system of telephonic and telegraphic communication should be provided by Government round the coast of the United Kingdom, and that all coastguard and signal stations be so connected, and that on those parts of the coast where such stations do not exist, the postal telegraph offices nearest to the lifeboat stations be telephonically or telegraphically connected."

Submarine Cables of the World.

There are now in existence 1,168 cable sections with a total length of about 143,011 nautical miles of cable. Of these 833 sections, or a length of 13,383 miles, are under the administration of different governments. France takes the lead with 3,269 miles, Great Britain follows with 1,599 miles, Germany with 1,579 miles, and Italy with 1,027 miles. The balance of 335 cables with a total length of 129,628 miles are the property of private telegraph companies. Nearly all this vast length of cable has been manufactured on the banks of the River Thames. Italy, however, has now a cable factory, and France last year turned out 1,500 miles from a factory at Calais, and a second factory is now in course of construction. To keep these cables in repair requires the exclusive services of 37 specially constructed and equipped telegraph ships, having a total tonnage of 56,955 tons. Ten of these are, however, kept almost exclusively for laying operations, and their tonnage amounts to 30,131 tons.

Electricity in Tanning.

The application of electricity to tanning is, we understand, meeting with ready attention and appreciation in Germany, where it seems manufacturers are ever ready to greet a new improvement with an open mind and to profit by it. Dr. Zerena, in dealing with the subject of electrical tanning, has recently said that the aim of those who are promoting it is not so much to produce any chemical change in the tanning liquor by the passage of the electric current, but to accelerate the physical action of the penetrating properties of the tannic acids in entering the pores of the hides. This could not be obtained by a uniform current, as the tannic acids would be unduly decomposed, while the alternating current, on the contrary, communicated the necessary "commotion," and produced firm, solid leather. Moreover, a steady current raises the temperature to too high a point. By using the alternating current, heavy hides have been tanned in thirty days of five hours each, the liquor being made from ordinary oak bark, with a small quantity of valonia added in the latter stages. As there are already many processes for tanning light hides and skins in successful operation, electricity would, according to Dr. Zerena, offer no special inducement to tanners of other than heavy hides; he hopes, however, that the results already obtained will lead to further experiments, and that electricity will eventually become generally used in the tanning of leather.

The Wornes and Balé System of Electrical Tannage.

We were favoured a few weeks ago by one of our readers, with some documents referring to this system, and samples of leather which have been tanned by it. These documents were full of promise and the samples of leather appeared to be excellent as far as could be judged, and it seemed a matter of wonder to us why the system has apparently not "taken" with the tanning world. The system is being worked by the "British Tanning Company" we learn, but so far there are not many signs of progress. Is it the fault of the managment or of the system itself? Either could be modified we should think if necessary. The company has been started nearly two years and it should be nearly time that some reports were published, for successful companies usually have yearly meetings of proprietors to congratulate them and disburse dividends, or ask for further funds to enlarge their operations. We learn, however, from one of the organs of the leather trades that the yearly statement of the affairs of the British Tanning Company is only published to shareholders and is not intended for the general public. We understand that some effort is being made to raise further capital but that the heavy working expenses combined with the small amount of business that is being done at present, and the large sum required to satisfy the claims of the patentees, keep this company in rather difficult circumstances. It is a great pity that a system which can undoubtedly produce good leather should be unable to be exploited for want of funds, and we hope that capitalists who are public spirited will come forward so that it may have a really fair trial. Tanners are not working with such perfect scientific systems that they can afford to allow a new system conferring alleged benefits to languish for want of attention. Personally we are interested in neither the Wornes and Balé process, nor in the Groth system, except in so far as they both strike out a new line and are pioneers of electricity in the industry of tanning.

A New Standard Cell.

In a patent specification (No. 22,482—1891), recently published, Mr. E. Weston, of Newark, America, describes a new standard cell, which he states is unaffected by temperature as regards its electromotive force. The principle of the new cell is dependent upon the discovery by Mr. Weston that the electromotive force of all cadmium salts is practically independent of temperature changes, a result probably due to the fact that such salts are equally soluble in hot and cold water. In making up the cell, which may be of the same type as the Clark cell, the electrolyte used is a saturated solution of cadmium sulphate in water, and the electrodes are an amalgam of cadmium and mercury, opposed to pure mercury and protosulphate of mercury. It is stated that a range of 200° F. does not alter the electromotive force of the cell more than the $\frac{1}{100}$th of 1 per cent.

CHANGES OF ELECTROMOTIVE FORCE, VOLUME AND TEMPERATURE BY MIXING ELECTROLYTES.

In a paper on "The Relation of Volta Electromotive Force to Latent Heat, Specific Gravity, &c., of Electrolytes," which was published in the August number of the *Philosophical Magazine* last year, Dr. G. Gore, F.R.S., discussed the effects of dilution upon the temperature and total volume of the liquids examined, and upon the mean amount of electromotive force of a voltaic couple immersed in them. This paper was noticed in the Electrical Review for August 28th. Dr. Gore has recently been examining in a similar manner the effects of *mixing* electrolytes upon the same phenomena; and a paper describing his results may be consulted in the *Proceedings of the Birmingham Philosophical Society*, vol. viii., part i.

The mixtures employed were examined in pairs of what Dr. Gore terms "isomeric mixtures." They were all of them dissolved in distilled water, and are divided into two groups, viz.,

1st section :—Acids + salts (for examining the substitution of acids);
2nd „ :—Salts + salts (for examining double decomposition).

All the substances employed were taken in the proportions of their chemical equivalents, and in each case the equivalent weight in grains of each ingredient was dissolved in 1,800 grains of water, and, after measuring their separate amounts of electromotive force, the two solutions were mixed, and the changes in their temperature, total volume, and electromotive force ascertained.

A cadmium platinum voltaic couple and a thermoelectric pile of German silver and iron, were used for measuring, by the method of opposition, the changes of electromotive force at ordinary atmospheric temperature, and the measurements are given in volts. The thermometer employed was capable of measuring ·01 C. degree. Details of the mode of experimenting, and of measuring the changes attending the act of mixing, have already been given in the paper referred to, and in another one on "A Method of Measuring Loss of Energy due to Chemical Union, &c., of Electrolytes." (See *Phil. Mag.*, Jan., 1892, p. 28, and Electrical Review, Jan. 29th and Feb. 5th, 1892.)

The results are carefully discussed under each section, and are arranged in several pages of tables which are too voluminous for reproduction here. But Dr. Gore's paper is too interesting and important to be dismissed without following him through the general conclusions which he deduces from his research.

He takes these results along with those already obtained in the research upon a method of measuring loss of energy due to chemical union, which is alluded to above. Together they show that when one electrolyte is added to another, each so affects the other during the act of mixing, that the total volume, the mean amounts of latent heat, and of electromotive force (and probably of other properties of the liquids, such as refractive power, transparency to various kinds of radiant energy, &c.) of each of the two substances are altered. Similar changes of volume and temperature are already known.

The fact established in this research that these three classes of results extensively agree with each other, indicate that they are connected with some very fundamental property of matter, whilst the absence of apparent agreement between them, observed by Dr. Gore in a minority of cases, is probably due to a minor circumstance; the lack of perfect agreement between the three different classes of effects, both with acids + salts and with salts + salts, shows that the phenomenon are less simple than at first sight they appear to be. As the molecules of all substances are in a ceaseless state of motion, it is probable that the alterations of volume, temperature, and electromotive force, are results of changes of amount of opposite motions of the molecules of the two mixed substances. According to this view, the loss of heat at the production of chemical and voltaic action are due to neutralisation and other changes of molecular motion.

If the changes of volume, temperature, electromotive force and total molecular energy are results of neutralisation of opposite or incompatible motions of the two substances, Dr. Gore is of opinion that we may infer that in a case of chemical union the molecular motion of the constituent A of a mixture of electrolytes so alters that of the one B, and the latter so affects that of the former, during the act of mixing, as usually to decrease the total volume, the latent heat, the mean amount of that portion of the molecular motion of each dissolved electronegative substance which is incompatible with the molecular motion of the positive metal, and consequently also the mean amount of electromotive force.

The results obtained by experiment in this research and in the one referred to (*ibid*) show that if A is an acid and B is a base, the total volume, the latent heat, and the mean amount of electromotive force are usually largely *decreased*. If A and B are both salts, these effects are usually feeble and variable. If A is an acid and B is a salt, these effects are usually *increased* in one mixture of an isomeric couple and *decreased* in the other. And if A is a halogen and B is a salt, the *increase* in one mixture of such a couple is frequently greater, but if heat is then applied, a large decrease usually occurs (*ibid*).

Dr. Gore considers that these effects may be largely explained by the opposite influences of chemical union and dilution upon the degree of freedom of molecular motion and consequently upon the electromotive force; *chemical union usually decreases and dilution usually increases the mean amount of electromotive force*, but the former produces a greater and more profound change than the latter.

In nineteen cases out of twenty the dilution of an acid or a salt solution by water was attended by an increase of mean amount of electromotive force (see "Relations of Volta Electromotive Force to Latent Heat, Specific Gravity, &c., of Electrolytes," *Phil. Mag.*, Aug. 1891, as if the substances were in some degree "dissociated," or had acquired a greater degree of freedom of molecular motion; the latter appears the most likely.

Similarly, when the ingredients of two different solutions which were mixed, did not chemically unite, but their solutions merely diluted each other, the increase of mean electromotive force was greater (or the loss of it was less) in proportion as the degree of intimacy of union was less, and the uncombined or feebly combined electronegative substance had greater molecular and chemical energy; thus, in the case of addition of an acid to a salt there was often a gain of electromotive force, because there was practically a dilution and an increased freedom of molecular motion of the acid unattended by chemical union; and if a halogen instead of an acid was used the gain was still greater, provided no chemical union occurred. (See "A Method of Measuring Loss of Energy by Chemical Union, &c., of Electrolytes," *Phil. Mag.*, Jan., 1892.) If, however, an acid solution was added to one of a base, there was usually a large loss of electromotive force, because there was chemical union, contraction of volume, loss of heat, and diminished freedom of molecular motion (*ibid*).

The fundamental conditions of the phenomena are relative velocity and direction of molecular motion. The greater the velocity of the molecules of the electronegative constituent of the liquid, the greater usually is the electromotive force, thus the halogens have greater molecular velocity, and produce a greater effect than acids, and acids than salts, and act more strongly upon the electropositive metal. The more opposite also in direction or incompatible the molecular motion of the electronegative constituent of the liquid after mixing is to that of the positive metal, the greater usually is the electromotive force; and the more opposite the molecular motions of an acid are to those of a base, the larger usually is the loss of energy and loss of mean amount of electromotive force during the union of those substances.

Relative degree of freedom of molecular motion, by influencing the molecular velocity, has great effect, thus—1st, Diluting an acid or saline solution with water usually produces an increase of mean amount of electromotive force, especially with strong acids, actual trial gave nineteen out of twenty cases (see "Relation of Volta Electromotive Force to Latent Heat, Specific Gravity, &c., of Electrolytes," *Phil. Mag.*, August, 1891, p. 157); 2nd, Add a solution of a salt to one of a salt, and there is but little gain of electromotive force, because the electronegative constituents of the salts, being chemically united to their respective bases, have but electronegative substances dissolved in it, is always greater, when the mean electromotive force is increased, because we know by experiment that in some exceptional cases the latter

is greater after the two liquids have lost molecular motion in the form of heat than previously (*ibid*). Some of the exceptional cases may probably be explained by the increase of electromotive force attending dilution.

Upon the basis of Newton's third law of motion, that action and reaction are always equal, we may in all cases conclude that the loss of energy in the form of heat during chemical union, and the absorption of heat during the mixture of any two electrolytic substances, is equally divided between them.

As the degree of volta electromotive force is a direct result of, and inseparably connected with, the strength of chemical action of the electronegative constituent of the liquid upon the positive metal, the foregoing general remarks on the relations of molecular motion to electromotive force apply largely to the relations of such motion to chemical action of that constituent on that metal, and the measurements of electromotive force are, to a certain extent, also measurements of strength of chemical action.

The chief new truth disclosed by this research is the distinct connection between changes of total volume, total heat, molecular motion, and *mean amount* of electromotive force. All the results obtained in this research help to confirm the existence of a mechanical basis of voltaic and chemical action.

INDUCTION BY HIGH POTENTIAL DISCHARGES.*

By ELIHU THOMSON.

It is well known that electric lines are strongly affected by induction during thunderstorms, and it would naturally be inferred that a line in a direction parallel to the flash would receive the strongest inductive influence, and that the induction would not necessarily be static induction, but currents would be set up by dynamic induction, complicated in many cases by static inductive actions occurring at the same time. What are known as "return strokes" in lightning flashes, according to this view, may be nothing more nor less than parallel induced discharges along fairly good conducting paths, and it is possible that in the neighbourhood of a lightning flash such induction may be of a very intense character.

These considerations led to my making the experiment of inducing, by a Leyden jar discharge, passed through a single turn of insulated wire, a discharge in a ring shaped vacuum tube placed alongside, which was found to illuminate the vacuum. Similar experiments had been made and published by Prof. J. J. Thomson.

In working to devise a means for the protection of electrical apparatus from the effects of such induced discharges of lightning, it occurred to the writer to employ the inductive effects of the discharges to counteract, as far as possible, the effects of such discharges, or, as it were, to interpose a barrier between the discharges and the apparatus to be protected. This gave rise to a lightning discharge protector or lightning arrester, the principle of which is shown in the accompanying figure. Let L be a line leading from a dynamo or other electrical apparatus, and subject to induction from lightning discharges, or subject to lightning discharges themselves, as in a railway trolley line. Let D represent a dynamo with one terminal grounded and the other connected to line. In such a case were there no provision for protecting the dynamo, D, from a lightning discharge it would be in danger of injury in case of induction occurring along the line, or in case of a flash reaching the line. To avoid this I place between the dynamo and the line a sort of induction coil which consists of a double coil, each coil being made of a few turns of coarse wire highly insulated from each other. One of the coils may be wound upon the outside of a glass cylinder and the other coil may be wound in the interior thereof. Both are connected to line at one end, as shown, and one or both are connected to earth through the discharge plates of a lightning arrester, A, provided with an arc rupturing device, such as a magnet, to blow out the arc in case the potential of the dynamo is high enough to maintain such an arc. The coil in the dynamo circuit has been found to need a few more turns than that in the earth circuit, and the direction of winding in the two coils is such that they are opposed in their inductions, or that a discharge passing from line to earth through one of the coils tends to induce a discharge in a direction toward the line in the other coil, or the coil in the dynamo circuit.

The manner of experimenting to determine the relation of the coils was substantially as follows:—A double coil was made in which the inner turns were about 12 and the outer turns 20. These were kept separate from each other, and a branch wire taken from the line and slid from point to point on the outer wire enabled the effective length of the same to be adjusted. The inner coil was connected through a small spark gap, as at A, to the outer coating of a Leyden jar, while the wire, L, was brought near the pole of the jar, which was continually being charged from a Toepler-Holtz machine. The discharge in passing from the knob of the jar to the wire, L, representing the line, passed by the inner coil. When a certain length of the outer coil was employed only a very short or almost imperceptible spark was obtainable at *a*. If the balance of the turns were disturbed by including more or less than the proper number of the outer turns not only did a vigorous spark occur, but the gap at *a* could be quite considerably extended, in accordance with the amount of departure taken from the proper number of turns required to produce the balance. This experiment indicates that it is possible to make a selective path for the Leyden jar discharge and to have, as in fig. 1, a structure so proportioned that the discharges

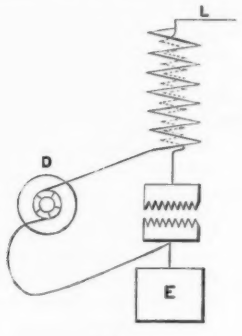


Fig. 1.

reaching line will pass to earth without tending to go through the circuit of the dynamo, D. The action is apparently due to a balance of electromotive forces, such that the discharge which tends to pass from the line in going to earth induces in the coil connected to the dynamo a counter electromotive force which nearly wipes out the potential of the discharge before it reaches the dynamo. This balance of inductive

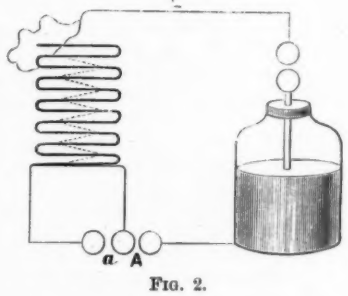


Fig. 2.

effects is certainly very striking, and once obtained it is disturbed, as in the experiments, by changing the relative lengths of the coils in inductive relation through so small an amount as an inch or two.

It may be mentioned here that some curious effects of spark were obtained in these experiments. When a disturbance of the balance exists and a spark is obtained at *a*, the character of the spark is different from that of the Leyden jar discharge. It appears to be less luminous, the noise less sharp and its colour would indicate a greater power of volatilizing metal and perhaps a greater duration.

* *Electrical World.*

It is in part no doubt due to a current local to the coils in series with one another.

Another curious effect was the production of T shaped and Y shaped sparks, or three branched sparks, such as are shown in figs. 3, 4, and 5.

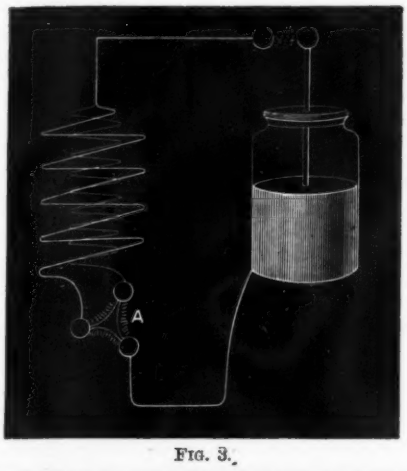


FIG. 3.

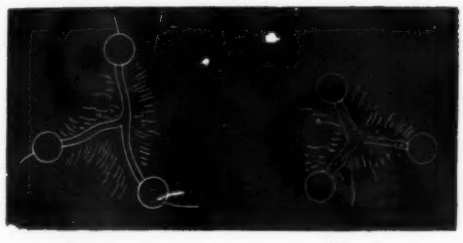


FIG. 4.

FIG. 5.

These were obtained by separating the electrodes at A, an inch and a half or thereabouts, and bringing the third electrode from the outer coil to the position shown in fig. 3. The discharges were now obtained as before from the charged jar. In this case the discharge appears to split and unite in air, producing the curious shaped sparks shown. It would seem that to obtain these effects, particularly the sparks which were three branched from a common point in the centre between the discharge electrodes, the dielectric air must break down simultaneously between the three electrodes. It would easily explain the T shapes to assume the straight part above to form first, and the cross or transverse spark to strike from the side of this spark to the third electrode.

The induction effects obtained with apparatus described soon led the writer to reason that the passage of heavy condenser charges through a coarse wire primary coil of few turns might be made to induce in a finer coil of more turns wound parallel thereto discharges of much higher potential and less current. In this case the Ruhmkorff coil would, as it were, have its primary subjected to the oscillations of a condenser discharge of high potential, instead of low potential battery discharges raised in potential by the condenser and interrupter.

On trying the experiment with a coarse, heavily insulated wire coil of 10 turns, enclosed in a glass tube, without any iron core, and with a secondary of one layer of fine silk covered wire outside the glass, it was found that the passage of the Leyden jar discharges of about half an inch spark in the coarse coil would give rise to such high inductive effects in the secondary as to spark from turn to turn in a single layer. By immersing the whole in a jar containing insulating oil, however, the insulation of the turns was better kept, and sparks of 2 or 3 inches were obtained between the terminals of the secondary at every discharge of the jar. The glass tube used was about 2 inches in diameter and about 5 inches long. There were about 120 turns in the secondary layer. The induction must have been at least as high as from 100 to 150 volts to the inch of wire. It was soon found that the glass tubes $\frac{1}{8}$th of an inch thick were frequently punctured under the oil, and that the spark of the jar could not be unduly lengthened without producing discharges under the oil, or between turns of the secondary.

The sparks from the secondary were peculiar in that they appeared to be prolonged and quite like those of a Ruhmkorff coil worked in the ordinary way, but with small condensing surfaces on each terminal of the secondary.

Arrangements were now made to obtain frequent condenser discharges at high potential, and to carry on the experiments on a much larger scale. The results have shown that it is now in our power to obtain torrents of long sparks, and that this may be done without any very great expense for apparatus, the expense being very great in the case of the large Ruhmkorff coils hitherto made. Sparks of 2 or 3 feet long will, I think, be readily obtainable. The sparks are like those obtainable from small jars, and if the terminals be connected to jars in the same way as the condensers are attached to a Holtz machine, the thickness of the sparks can be increased at a sacrifice of length.

I will now describe the apparatus I use. This will give a torrent of sparks of 7 to 8 inches in length making a loud roaring sound, and the length of spark seems limited only by the capacity of the secondary coil to maintain the insulation. This will be improved in the next construction.

In fig. 6 is a view of the apparatus used, A is a large induction coil or transformer capable of using in its primary ordinary alternating lighting currents of 50 to 100 volts and transforming up to 10,000 to 12,000 volts alternating. So used it will spark over one-half inch to one inch between its terminals and give the uprising thin arc now well

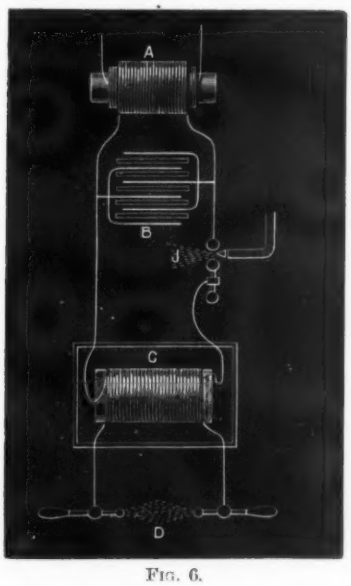


FIG. 6.

known. A blast of air blown on such an arc changes it into a beautiful pale purple flame. A condenser, B, the capacity of which can be changed, is connected to receive the current from the secondary of A. The spark or arc with moderate condensing capacity is not much changed unless a blast of air be blown upon it. In this latter case it becomes a most beautiful electrical phenomenon. It becomes a mass of flame filled with fine and thick shreds representing the condenser discharges, a gorgeous network of electric fire changing with any change of the pressure or the direction of the air blast. Sometimes, as on breaking the primary circuit, the oscillations of charge and discharge are seen as minute parallel lines or sparks on the borders of the flame joining the terminals. With greater condensing surface the discharge between terminals becomes more thick and white even without the blast, and when a forcible air jet is turned on it roars very loudly. At C is a second and peculiar transformer, the primary of which is an open helix of but a few turns, as 15 or 20 convolutions of heavily insulated line wire about four or five inches in diameter. This is surrounded by a thick glass cylinder upon which has been wound say 150 turns of fine silk covered wire in one layer with a silk thread between the turns so as to cause the turns to be well insulated laterally. This

simple induction coil is now immersed in a jar of heavy oil and the terminals on leaving the oil kept as far apart as possible and surrounded by glass tubes. The terminals of the coarse and short primary are connected in circuit with the discharge balls upon which the jet of air plays at J. The finer secondary terminals are connected to discharge terminals as at D, for obtaining the spark. On passing the alternating currents in the primary of A and adjusting the spark gap and jet at J as well as the distance between the discharge terminals at D, it is easy to obtain sparks of seven to eight inches in a perfect torrent at D, while sparks of $\frac{1}{4}$th inch are passing at J.

In fact, coil A and condenser jars, B, constitute the source of very rapid electric oscillations and correspond to the primary battery and condenser of a Ruhmkorff coil, while the air jet and spark gap at J bear a similar relation to the interrupter.

The discharges obtained at D represent, it would appear, at least 150,000 volts in potential, or about a thousand volts to each turn of the secondary. The potential may be higher, for we have no data of spark length at such high pressures. It should be mentioned that the limit of spark was apparently that of the insulation of the secondary turns, for on attempting to increase it by separating the terminals at D to over eight inches, the sparks jumped in the jar of oil and could be seen passing under the oil from the secondary to the primary wires. Were it not for the required insulation between the turns of the fine wire secondary of C, they could be wound in one layer so as not to cover more than two or three inches of the glass cylinder, and could be made to give out sparks of a foot or more in length. The volts per inch of wire obtained in these experiments are extraordinary, and it is quite certain that the limit will depend on the insulation. We are now possessed of the means for obtaining artificial lightning in a steady stream, and can experiment at will with extremely high voltages. The advantages of oil insulation are emphasized by these experiments, and although sparks frequently passed under the oil the insulation is renewed at once.

It is necessary that the coil, C, be sunk well below the surface of the oil as otherwise the discharges will perforate the oil layer at each end and pass over the surface. It is curious to note the agitation of the oil over the coil when the apparatus is in action and the coil is not deeply immersed and yet sufficiently so to prevent discharge. A curious discharge without electrodes is obtained by providing each terminal of the secondary layer, C, with a metal plate which the oil just covers, the plates being parallel to the oil surface, figs. 7 and 8. Great agitation of the oil over the plates

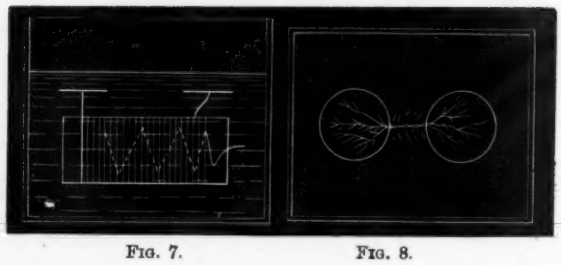


FIG. 7. FIG. 8.

ensues and sparks pass over the surface of the oil and spread over the surface just above the plates. If the oil layer be too thin it is perforated by discharges passing from plate to plate and oil is scattered. Geissler tubes are lighted in the vicinity of the coil, outside the jar or near the terminals, an action long well known in the case in the working of Ruhmkorf coils of considerable power. The frequency of the alternations used was 125 or 250 alternations per second. By raising the alternations the spark torrent will be more continuous. On the completion of still more powerful and perfectly insulated apparatus the effects will doubtless be greatly enhanced.

The experiments demonstrate that lightning discharges, aside from electrostatic effects, may be the source of most vigorous electrodynamic inductious, and that high potential discharges may result. The bearing of this on a "return stroke" has already been mentioned.

It may also be pointed out that in the electro-dynamic inductions set up we have a means for the study of the rate of oscillation, potential, and current, of lightning discharges which are now but little understood. It is too much to assume that all such discharges take the oscillatory character of Leyden jar discharges, and it would be useful to distinguish between rates and characters of discharge. The writer remembers that during a storm a few years ago he noticed a ringing or humming sound accompanying a not very distant flash of lightning. The sound was remarkably clear and almost musical. Could it have recorded the oscillations of a discharge in which the capacity and self-induction were such as to give the oscillations a defined rate within the ordinary range of pitch of musical sounds? It is an observation which the writer takes the present occasion to record, as a strong impression was made on him on account of the loud, clear ringing tone which followed the flash.

SYNOPSIS OF THE HISTORY OF OZONE—1840 TO 1892.

(Continued from page 99.)

1880.—Berthelot shows that ozone is formed with absorption of heat, which it liberates while oxidising. It is the only element which has two distinct gaseous isomeric modifications.

Douglas Galton writes on the beneficial action of ozone on general health. The permanent absence of ozone from the air can be regarded as a proof that the air is contaminated.

Berthelot upsets the theory of Schönbein, Rivier and Fellenberg on the formation of nitrous compounds, on the basis that if ozone is nitric acid or nitrous acid, the two acids accompany ozone.

Mumené says that nothing can explain the electrification of oxygen, and that nothing justifies formation of O_3. According to him, O_2 or O_4 is formed, and when electrolytic oxygen is generated, it contains oxygen, ozone and peroxide of hydrogen.

Hautefeuille states that oxygen does not show phosphorescent glow, which is the characteristic of the electric effluvia.

Articles of the *American Journal of Applied Chemistry* on the powerful action of ozone upon organic substances, recording the statement of Dr. Sehan, of Berne, that ozone as well as substances impregnated with it, kill animalculæ, and that ozone must be used in hospitals as disinfectant.

Hautefeuille and Chapuis declare that a mixture of oxygen and nitrogen does not supply ozone, and that chlorine destroys ozonised oxygen.

The action of silent discharges is more productive of ozone than a machine, which does not ozonise when the spark is weak, and which destroys ozone when the spark is powerful and generates nitrogen.

The ozonisation is better when oxygen is mixed with a gas; it is more advantageous to electrify atmospheric air than pure oxygen. Comparison of the assertion by Berthelot that the silent discharge does not combine oxygen with hydrogen, with the statement made by Perret in 1861, that a single spark does so.

Hodge Brothers bleach sugar by ozone; in the bleaching by chlorine the decolorising power is acted not by chlorine, but by ozone.

W. L. Thompson, in America, desulphurises auriferous ores by ozone.

1881.—René, a German piano maker, takes a patent for eliminating rosins and fatty substances contained in wood, by means of ozone. He uses a large influence machine and passes ozone through stoves containing planks.

Experiments made by Dehérain and Maquenne on the effluvia in a wet atmosphere, by means of the Berthelot and Thénard tubes.

Naudin and Schneider attribute the properties of ozone to a condensation of oxygen, and according to them, the so-called nascent state is a condensed state of matter.

Eisenmann starts in Berlin a factory where he refines raw spirits by ozonised oxygen.

Ozone is applied to the transformation of alcohol into

aldheydes: $C_2 H_6 O$ or $C_2 H_4 O_2$, which, according to Roscoe, is used for making green aniline.

1882.—Paper by Dr. Binn, of Berlin, on ozonised air as an anaesthetic.

Yost, in America, patents an ozonising tube for rooms in combination with a battery, an induction coil, a motor and a fan.

Maxwell Lyte stating the beneficial results of ozone for the treatment of raw spirits, writes that its manufacture is costly and uncertain.

The *Textile Colorist* and other technical papers mention the Maillart bleaching by ozonised oxygen, but this process is merely the well-known laboratory experiment of the action of ozone produced on a very small scale in a tube.

Böttger detects the presence of ozone by means of neutral bichloride of gold which turns blue.

The Patent Office refuses the provisional protection to the German, Sandemann, for transforming alcohol into acetic acid by ozone.

The Académie des Sciences grants the Lacaze prize to Hautefeuille for the progress he caused to be made in the production of ozone.

Application of ozone for rapidly oxydising varnishes.

1884.—Dr. C. Lender of Berlin, successfully experiments with the inhalations of ozonised oxygen in the treatment of wounds. His pamphlet on impure blood and its purification by negative-electric oxygen.

Dr. Sass studies the therapeutic effects of ozone and obtains encouraging results.

Von G. Vulpius employs ozone water for diphtheria.

Observations by Wiedemann on the drawbacks of static machines in which dust accumulates on varnish; the glass is soon worn out and wants frequent renewals.

Report of Dr. Onimus on the cholera in Paris and Marseilles and on the influence of ozone; his conclusion is not that the absence of ozone causes epidemics, but that it facilitates its generation and that the presence of ozone prevents the spreading of the contagion (see *Nature*, Dec. 25th, 1884, "Variations of the Ozone"; and October 8th, 1885, "Action of Ozonised Air on Micro-organism)."

1885.—Daniell, in his Text-book on the "Principles of Physics," says that when two metal tubes, the one charged positively and the other one negatively, are placed one within the other, so as to have an annular place between them, sometimes chemical effects take place and oxygen is partially transformed into ozone.

Bartley in his "Textbook of Medical Chemistry," says that ozone in appreciable quantities acts as a purifier of the air, destroying by its oxidising action many forms of organised germs, hurtful to animal and vegetable life.

1886.—Formation in New York of the Ozone Machine Company (Henry Hall system by means of a static machine). Its object is to place ozonisers in apartments, private residences, public buildings, theatres, hospitals, and also to create a dispensary for patients.

Purification of water by ozone (see *Journal of Chemical Industry*), 1886, p. 650).

Bendix in the *Zeitschrift für Spiritus Industrie*, 1886, p.227) discusses the question of the employment of ozone for producing fine spirits and removing fusel oil.

Fahrig and Bolling produce ozone to bleach and refine raw sugar; the current is sent by a high tension dynamo through networks or sieves of platinum, separated by non-conducting porous plates; later on they use corrugated plates, made of a non-conducting material, coated with a metallic foil.

Phosphorescence of ozone by Fahrig (see *Chemical News*, 1890, pp. 39—61.

Fahrig calls ozone an electric gas, but the *Chemical News* protests, as a matter of principle, declaring that chemists cannot allow a new name to a substance, under pretext that it is produced by a new process.

Experiments by Thompson and Threlfall, their apparatus.

The *Electrical World* comments on the action of ozone on decaying and putrescent organic matters which are converted into innocuous bodies; its conclusion is: as a disinfectant, its value is indisputable, but up to the present there is no convenient method of producing ozone, so that it could be universally applied.

1886.—Broyer, a French distiller, patents a process for improving spirits and wines by the triple electrisation of oxygen; he uses the ordinary tubes of Houzean and Berthelot.

Dr. Teillard starts a factory where a few hogsheads are treated every day by the Broyer process.

Brin Brothers try to manufacture ozone, the applications of which they patent for different purposes: bleaching paper, oils, sugar, &c. Their ozone generator consists of three U-tubes, two of which contain granulated substances which conduct electricity (iron, copper, zinc filings or plumbago); in their apparatus ozone is formed in the inter-annular space. In each tube containing the conductive substance is immersed a metallic rod acting as conductor.

Shenstone and Cundall recommence the experiments made by Andrews, Tait and Brodie, who did not electrify pure dry oxygen. The yield of ozone in their experiments is 11·7 per cent., while generally the ozonised oxygen represents only six per cent. of the quantity of gas submitted to electrification.

1888.—Charles Philippart files a patent for the production of oxygen in stable and unstable conditions, of oxygenated water and of ozone, an induction coil, or otherwise being applied to act on oxygen in circulation. No description of apparatus.

Dr. Thorne on the ageing and maturing of spirits by oxygen in nascent state, gives the following figures:—

	Fusel oil.
1. Whiskey before treatment	2 gr. per litre.
„ after „	0·06 „
2. Whiskey before treatment	0·3 „
„ after „	0·06 „
3. Whiskey (quite new Scotch) before treatment	1·63 „
„ „ „ after „	0·42 „

In concluding, he says: "From these numbers it is clear that the effect of ozone is really to mature and improve the spirit, and to convert the harmful fusel oil into innocuous compounds. E. A.

(To be continued.)

AN INSTRUMENT FOR DETERMINING THE PHASE OF ALTERNATING CURRENTS IN TRANSFORMERS AND BRANCH CIRCUITS.

A NEW instrument has been added to the equipment of the electrical laboratory, which promises to be of considerable utility in determining questions of the phase of alternating electric currents in transformers and in branch circuits. This instrument has been evolved by Prof. J. Trowbridge, of the Jefferson Physical Laboratory, Cambridge, U.S.A., in the course of certain investigations in magnetism, and has been named the phase-meter or "phasemeter."

It is well known that it is necessary to employ two or three electro-dynamometers in order to detect magnetic lag and changes of phase in the subject of alternating currents of electricity. The new instrument shows changes of phase, which are difficult, if not impossible, to observe in any other way. It is likely to be of especial use in studying hysteresis.

The phase-meter is based upon the method employed by Lissajoüs in investigating the vibrations of sounding tuning-forks, and which was afterwards adopted by Helmholtz in his vibroscope. Two telephone diaphragms are provided with mirrors. A beam of light is reflected in such a way that the vibration of one telephone diaphragm gives a spot of light a horizontal motion, and the combination of the movements of both diaphragms gives a figure which indicates the relative amplitude of the motions of the diaphragms, and also the difference of phase of the currents which set the diaphragm in motion.

Prof. Trowbridge first employed a system of levers in order to amplify the motions of the diaphragms. But owing to the liability of these levers to communicate vibrations peculiar to themselves, and thus to superimpose what may be termed sympathetic vibrations on the diaphragm, he was led to abandon this system, and to affix a stylus to the centre of the telephone diaphragm which touched a little mirror, which was delicately placed on a hardened steel point on which it could rock. This method of amplifying the motions of a telephone diaphragm was employed by Prof. Eli Brake, of

Brown University, in 1878, and is a very sensitive arrangement.

Prof. Trowbridge soon perceived that the mirror and its supports needed to be carefully tuned to the note to which the diaphragm was to respond, and in adopting the same method Herr Wien has added peculiar attachments to meet this difficulty in his so-called optical telephone for the measurement of alternating currents [*vide Wiedemann's Annalen*, xlii., p. 593].

The modification employed by Prof. Trowbridge is less sensitive, but seems to suit the phase-meter better. Two Bell telephones are provided with diaphragms of 3 inches in diameter; these diaphragms are not clamped equally round their edges, but are tuned to the note given out by the alternating current employed, by touching the diaphragm at its edges at suitable points by means of clamps which could be moved round the edge of the diaphragm until a mirror attached to the diaphragm showed that the latter moved in unison with the current. By turning the telephones around the axis of their magnets, the vibrations of the mirrors are adjusted so that they take place in planes at right angles to each other. Thus, when one telephone is cut out of the circuit, the other gives a straight line of light, indicating that the mirror is moving in unison with the diaphragm.

As a source of light, we are surprised to find that Prof. Trowbridge employed the Welsbach burner, since Captain Abney, one of the highest authorities on optical matters, has stated that he prefers the use of the electric light in optical investigations, because of the high and uniform quality of the light.

In the phase-meter, as used by the professor, a tin chimney is slipped over the glass chimney of the lamp. In the tin chimney is a circular opening of one half inch in diameter. Over the tin chimney, in turn, is slipped a closely fitting thin white paper chimney, and a pin-hole is made in this at a point which corresponds with the centre of the aperture in the tin chimney. By this arrangement the figures produced by the movement of the two telephones can be seen against the cross hairs of the observing telescope, and diffraction phenomena are eliminated.

Prof. Trowbridge is at present employing this phase-meter in the study of the propagation of magnetic disturbances around rings and over straight bars of steel and iron, and he has, we understand, from the American *Journal of Science*, obtained some interesting results, which will shortly be published.

THE COST OF ELECTRIC LIGHTING.

Our contemporary, *The Engineer*, in a recent issue, gives some interesting figures relative to the cost of running an electric light installation in the steam mills of Messrs. Walmsley and Smith, Barrow-in-Furness.

The installation includes one of Messrs. Mather and Platt's No. 5 dynamos, put down in 1885, to supply from 150 to 200 Swan incandescent lamps of 20 candle-power, at 100 volts. The dynamo runs at 1,115 revolutions per minute. This is driven by a horizontal engine of 10 nominal horse-power by Messrs. Marshall, Sons and Co. It has a cylinder 10·5 diameter, 16 inches stroke, and runs 120 revolutions per minute. It is supplied with steam at 65 lbs. per square inch, is steam jacketted, and is fitted with automatic expansion gear and Hartnell governor.

The dynamo was started on the 6th March, 1885. The original outlay was £396 12s., and subsequent additions brought the total outlay to £420 10s. 11d., but this includes a valuation put upon a few things from mill stock. The installation was carried out by Messrs. Mather and Platt.

The indicated horse-power, taken over three years, varied from about 12 to about 20, with a maximum of 25·9 with different numbers of lamps in circuit. The lamps per indicated horse-power varied from 6 to 8·2, but was almost always over 7, so that an average, without taking unusual extremes, would be as near as possible 7·8. The friction of the engine shafting and belts was 5·3 indicated horse-power.

The fuel consumed by the engine is taken as 3·5 lbs. per indicated horse-power.

The following shows the :—

General Working Expenses, Maintenance, and Renewals.

	1885-6.	1886-7.	1887-8.	1888-9.	1889-90.	1890-91.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Interest on capital at 5 per cent.	20 0 0	19 0 0	18 1 0	17 3 0	16 5 9	15 9 3
Depreciation	20 0 0	19 0 0	18 1 0	17 3 0	16 5 9	15 9 3
Fuel consumed (calculated*)	22 5 6	26 16 3	22 9 6	26 5 0	34 10 0	47 17 6
Lamp renewals	22 5 0	24 16 0	14 8 0	13 4 0	9 8 0	9 10 9
Brush renewals	6 14 0	1 16 0	0 18 0	0 18 0	2 14 0	0 18 0
Commutator renewals	8 10 0	6 15 0	...	6 15 0	8 10 0	...
Fixing commutator and repairing ditto	4 8 7	1 18 0	0 10 0	0 17 6	1 7 6	0 10 0
Sundries and renewals	0 19 0	...	0 9 6	9 14 2	1 4 0	...
	105 2 1	100 1 3	74 17 0	91 19 8	90 5 0	84 14 9

* At 3½ lb. per indicated horse-power per hour.

Details of Lamp Hours and Lamp Hour Cost.

Number of hours run	3,163	3,234	3,318	3,621	3,539	3,477
Average number of lamps lit	100	115	104	107	110	127
Number of lamp hours	316,300	371,910	345,072	387,447	389,290	441,579
Cost per lamp hour	·079d	·064	·052	·056	·055	·048
Number of lamps lit—one hour for 1d.	12·6	15·6	19·2	17·8	18·1	20·8

Dynamo Renewals and Repairs.

Number of lamps renewed	95	124	72	66	47	59
Number of times commutator turned	8	3	3	3	4	2
Number of brushes used	8	2	1	1	3	1

Number of lamps originally erected was 133; since then 28 have been added; total, 161. Cost of installation (including special 10½ in. engine) = about £400. Type of lamp used, Edison-Swan, 16 C.P., 100 volts. The average life of each lamp was 3,384 hours.

Averages for Six Years.

Annual cost, £91 19s. 11d. Cost per lamp hour, ·059d. Number of lamps lit, 1 hour for 1d. = 16·9. Hours run, 3,392. Lamps lit, 112·1. Lamp hours, 380,243. Cost of gas in Barrow = 3s. per 1,000 cubic feet. Cost of equal number of No. 5 burners, consuming 5½ cubic feet per hour at 3s. = £313 13s.

It will thus be seen that the light was practically obtained at a cost which would be about equivalent to gas at 11d. per 1,000 cubic feet.

Of course, as is pointed out, the fact that no men were specially employed to run the installation must be taken into consideration in estimating the value of the figures, and the latter as they stand are not by any means indications which can be taken for the purpose of showing the cost of running the light in a central station or in a private mansion.

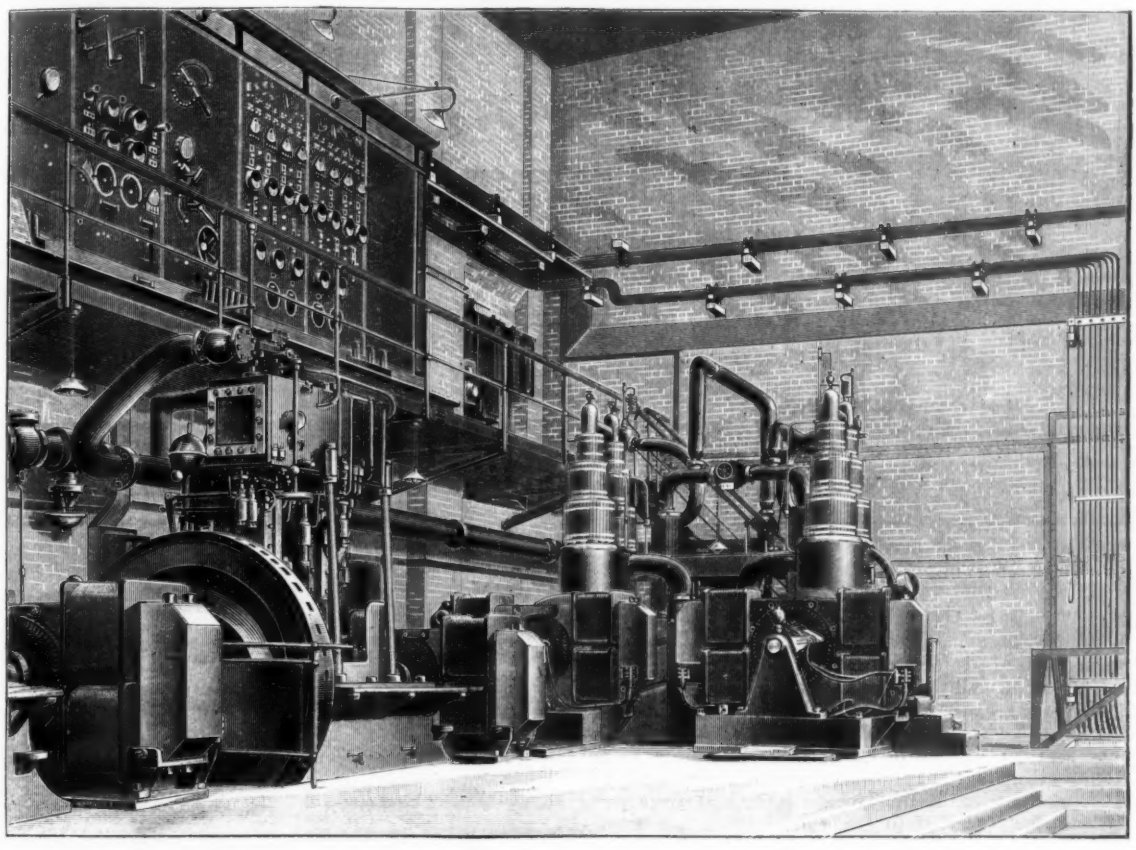
A SUPPLY STATION OF THE WESTMINSTER ELECTRIC LIGHTING CORPORATION.

THE area over which the Westminster Electric Supply Corporation has power to supply the electric light, comprises parts of the rich and populous districts of Belgravia, Mayfair and Westminster. The neighbourhood is not strictly a residential one, for besides private dwellings, there are numerous offices, shops and several of the chief public buildings. It is a locality which, under ordinary circumstances, requires a fairly constant supply of current, although there are occasions when the capabilities of the supply station are stretched to their limits. The system generally used is the low tension feeder with secondary batteries. The district is supplied by three stations situated in Millbank Street, Westminster; Eccleston Place, Belgravia; and Davies Street, near Oxford Street. At the time of writing, Millbank Street and Eccleston Place stations work in parallel, and when the Davies Street station is changed over to the three-wire system, which will be done in the autumn, the whole of the supply will be in parallel. An arrangement such as this will, no doubt, give economical results, and the future figures relating to cost, maintenance, &c., will be of special interest to engineers.

Like most other London companies the history of the concern does not go further back than the last three years, when the districts and parishes of London were apportioned out by the Board of Trade. Current was first supplied by the Westminster Company a little over fifteen months ago, from the station in Millbank Street. At this period the principal supply was taken by the Houses of Parliament, but there was a quick demand on the part of the public for light, and the whole of the output was taken up in a short time. The Eccleston Place station, commenced to supply current in the early part of last year, and Davies Street began operations a few weeks later. Neither of these stations are yet out of the builders' hands, although they are rapidly approaching completion. Mains have now been laid throughout the specified area.

The central station at Eccleston Place is the one which we purpose to describe in this article. It is the intention of the Corporation to make this the centre of the system, and a large building has been erected in which there is ample room for the general offices of the company, engineer's rooms, and stores. The ground space occupied is considerable, and as the neighbouring land has been either bought or leased, future extensions will be easy.

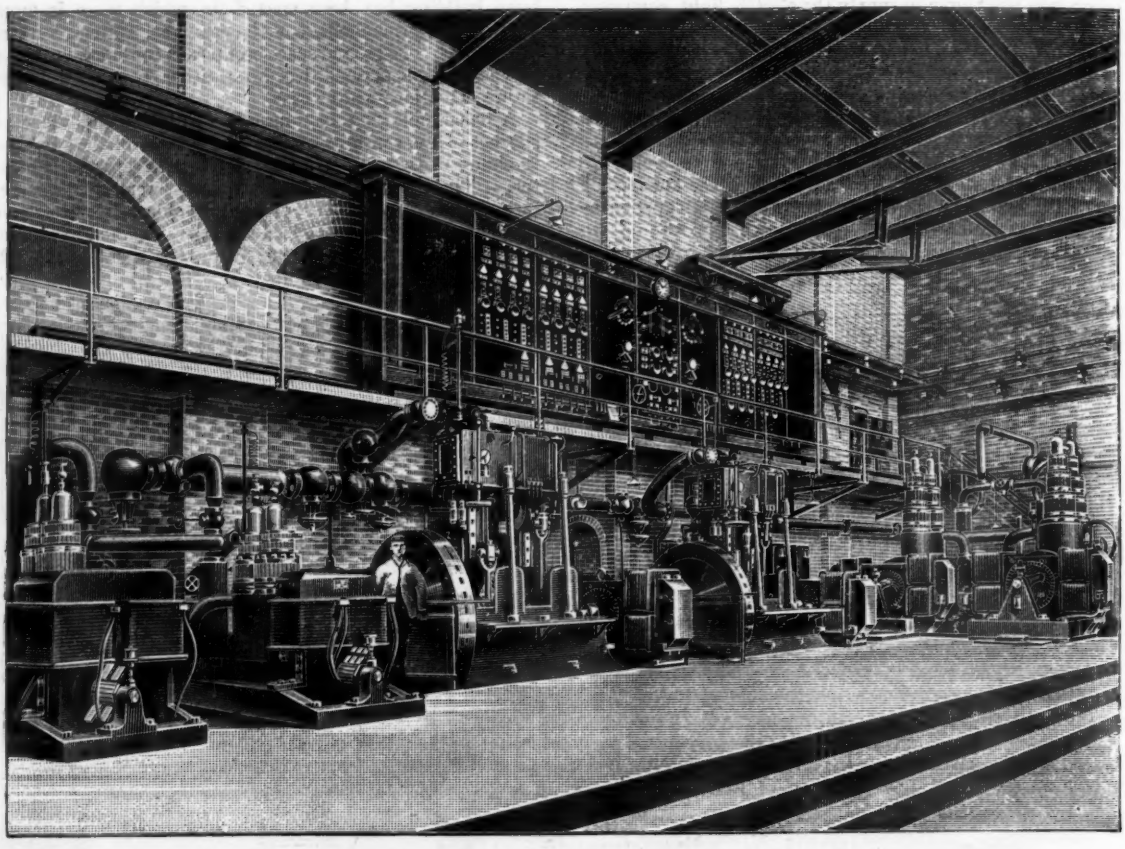
A remarkable fact in connection with this and the other stations of the company, is that each section of the work has, in almost every case, been carried out by a separate contractor. The designs and specifications were, in the first instance, prepared in the company's offices by Prof. Kennedy, and afterwards boilers, engines, dynamos, pipes, &c., were each ordered direct from their respective makers. All the architectural work for the company has been planned throughout by Mr. C. Stanley Peach.



INTERIOR OF STATION.

It was on the 2nd of March, 1891, when current was first supplied from Eccleston Place station. At this period the generating plant was covered by a wooden shed; the brick walls of the station were built round this, and when the shed was at last dismantled the building was almost finished. A fortnight had scarcely elapsed before the whole output of the station was utilized. The supply of current was first obtained from two Siemens dynamos of a capacity of 300 ampères each, though they seldom worked to give less than 380 ampères. In these dynamos the iron core of the armature is composed of sheet iron discs 20 inches in length, 14 inches diameter, and wound with 152 stranded bars of rectangular section. The commutator has 76 parts and takes three 2-inch brushes on each side. The field magnets are of wrought iron 9 inches thick, and supported from the base plate by gun-metal side brackets. At the moment they are used mainly for the day supply, and for charging batteries, and at night serve to balance the load. The main supply is ob-

tained from a set of four 4-pole Crompton dynamos of the latest type, two having a capacity of 300 ampères at 225 volts, and the other two a capacity of 500 ampères at 240 volts. Our illustrations show these machines coupled



Another View of Station Interior.

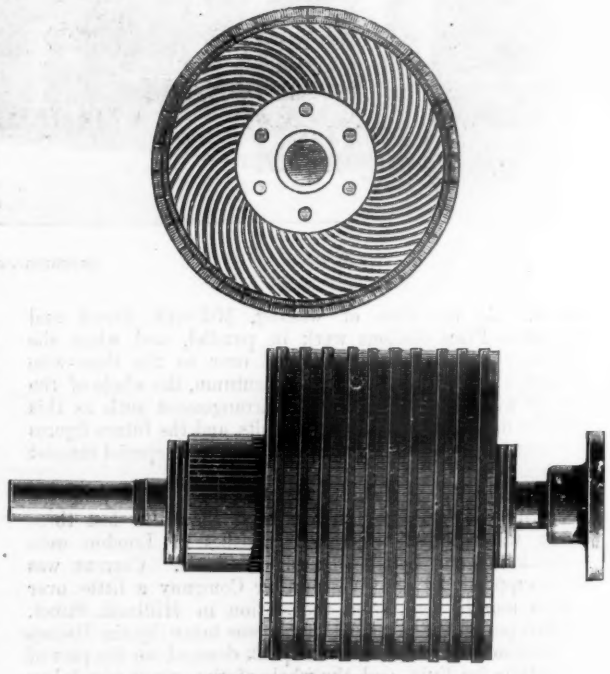
with Willans triple expansion engines, and compound "Windsor" type engines made by Messrs. Davey, Paxman and Co. It is found that the combined efficiency of a Willans engine with these dynamos is very high, and 84 per cent. is spoken of as being reached. They run almost sparkless, and come well within the Admiralty specification for temperature. The construction of the dynamo is very simple, and extremely strong. The magnets consist of four forgings of soft annealed wrought iron yoked together at their outer ends and securely bolted to the bedplate by means of gun-metal brackets. The magnet coils, four in number, are wound on separate formers with substantial wooden flanges.

The principal feature of the dynamo is the armature. This is of a very rigid and massive construction, and consists of a core, built in the usual way, of insulated charcoal-iron discs, mounted on a substantial steel shaft. The winding of the armature is a modification of the usual drum winding. The armature bars consist of a number of turns of Crompton's patent pressed cable. The end connections consist of a number of copper strips bent to the proper form and soldered at one end into the commutator plates, thus doing away with extra commutator lugs. At the other end of the armature the connectors are soldered into a segmental hub built up in a similar way to a commutator. This arrangement gives very great security and strength for driving.

The engines, by Messrs. Willans, which are coupled to the Crompton dynamos, are two I. I. (two crank) triple expansion. The high pressure cylinder measures 10 inches diameter, the intermediate, 14 inches diameter, and the low pressure is 20 inches diameter, with a 9-inch stroke. Each engine will indicate up to 200 H.P. when running at a speed of 355 revolutions.

In addition, there are two G. G. (two crank) Willans compound engines, coupled to the Siemens dynamos. The measurement of the high pressure cylinder is 10 inches and the low pressure 14 inches. The stroke is 6 inches.

As will be generally known to our readers, the Willans

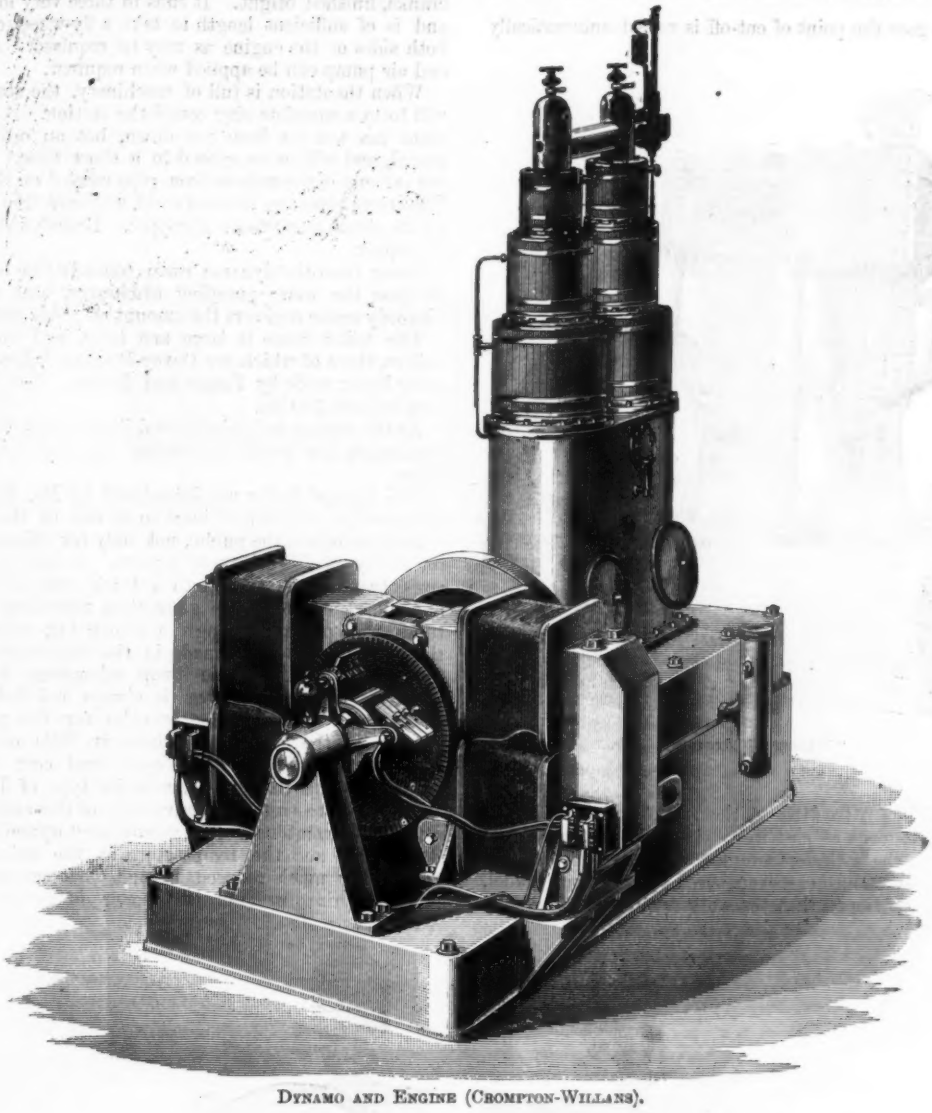


Crompton Armature.

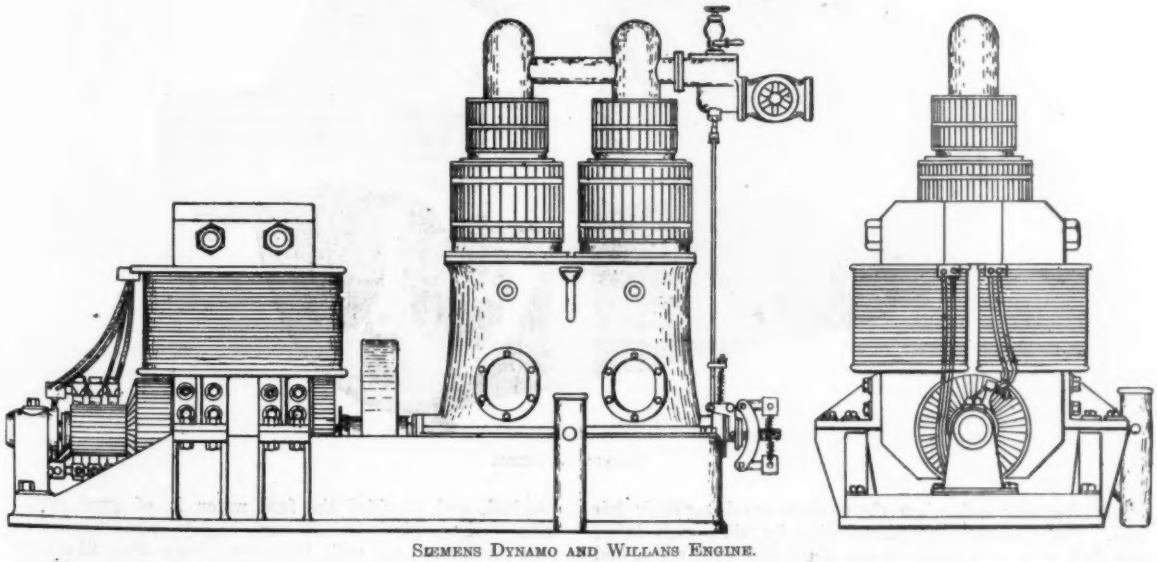
engine is single acting, with the brasses constantly in compression, thus obviating knocking when running at full speed.

In this engine the piston speed is lower than that in most other engines, consequently the wear in cylinders and pistons is small. The valves, which are of the piston type, work inside the piston rods, and give good distribution of steam and drainage for water.

The remaining two large dynamos are coupled to vertical compound engines, made by Davey, Paxman & Co., and styled by them the "Windsor." This engine, which we illustrate, is one, which for an open machine, occupies a small space in proportion to its power, and the excellence of its governing allows the output to be perfectly controlled by shunt resistances. The wearing surfaces in this engine are very large,



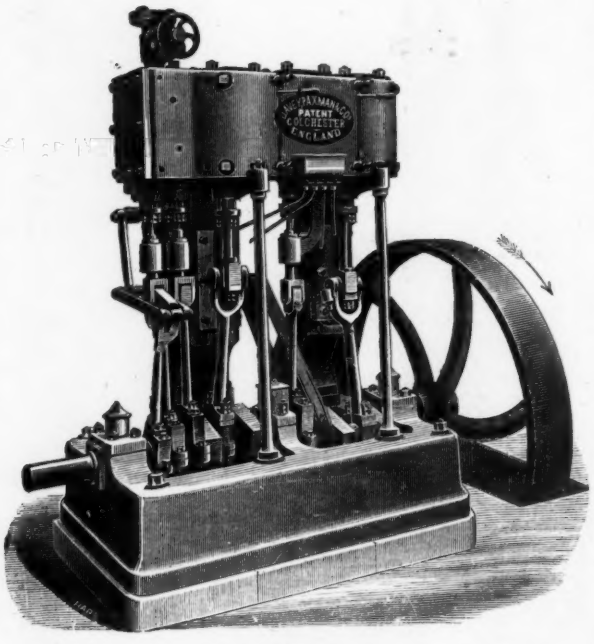
DYNAMO AND ENGINE (CROMPTON-WILLANS).



SIEMENS DYNAMO AND WILLANS ENGINE.

which permits of running for long periods, and ample means are provided for lubricating. It is fitted with Paxman's automatic expansion gear and high speed governors.

With this gear the point of cut-off is varied automatically



"Windsor" Engine.

as required from 0 to ⅝ths of the stroke. The bed-plate is in one piece, made of cast iron. It is of neat design and very strong. The cylinders are made of a hard and special mixture of close-grained cast-iron, bored out true and parallel, and are so proportioned that the work done is about equally divided between each when the engines are doing their fair load. The cylinders are placed side by side, each being provided with a separate steam chest and slide valve, and they are mounted on the top of strong cast iron back standards and supported by steel columns in the front. The piston rods, crossheads, and slippers, are forged from one piece of steel and adjustable brasses are fitted for the crosshead pins. The slipper guides are bolted to the front of the standards. The crankshaft is of mild steel, with slotted cranks, finished bright. It runs in three very long bearings and is of sufficient length to take a fly-wheel on either or both sides of the engine as may be required. A condenser and air pump can be applied when required.

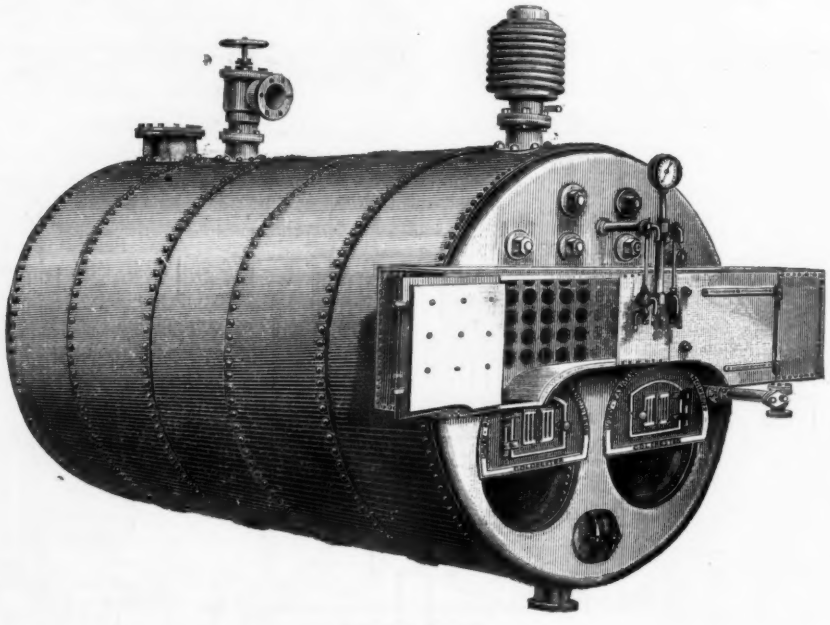
When the station is full of machinery, the steam exhaust will form a complete ring round the station. A condensing plant has not yet been put down, but an order has been placed, and will be completed in a short time. At present, the exhaust is through an iron pipe carried up the chimney. The steam pipes are made of steel, with cast iron stop valves, all the bends being made of copper. Branch steam pipes are of copper.

Going from the dynamo room towards the boiler house, we pass the water pumping machinery, near to which a Kennedy meter registers the amount of water used.

The boiler house is large and lofty, and contains four boilers, three of which are Davey-Paxman "Economic," the other being made by Fraser and Fraser. The steam pressure is about 150 lbs.

As the marine boiler has found little acceptance in central stations, a few words concerning this may not be out of place.

This type of boiler was introduced by Mr. Paxman some 30 years ago, and it is claimed to be one of the best steam generators before the public, not only for efficiency, but for durability and facility of repairs. It has (in the larger sizes) two flues emptying into a brick combustion chamber at the back of boiler, the gases then returning through the tubes, and passing through a smoke box which conducts the gases to the flue made in the brickwork round the outside of boiler. One great advantage is that this brick combustion chamber is always red hot, and thus at the back of the boiler provides for the perfect combustion of the gases, and there is little or no smoke. These boilers occupy less space and cost considerably less for setting than the Lancashire type of boiler, whilst they are said to possess the advantage of this and the multitubular boiler combined. The gases are cut up and more equally distributed, and the temperature at the chimney is held to be very much reduced beyond what can take place in a Lancashire or Cornish boiler if only moderately worked, and provided the feed water is of good quality, the "Economic" boilers are highly recommended by the makers. As will be seen from the illustration, this boiler consists of a cylindrical shell, with one or two internal flues (according to size of boiler), and a number of smoke tubes running from end to end of the



Economic Boiler.

boiler. It is provided with Paxman's patent expansion boiler flue, the form of which gives it such strength that thinner plates can be used in its construction than it would be safe to use in the plain flue. This is a great advantage, as it is a well-known fact that the heat passes more rapidly through thin plates, which are thus rendered more durable, because they do not become overheated. In this way the full excellence of the material is retained for a considerable length of time. It is also well known that the strength and durability of a boiler depends greatly on there being proper provision made in its design for expansion and contraction. Where this is not provided for, furrowing and ripped seams are the inevitable result. Paxman's patent expansion boiler flue,

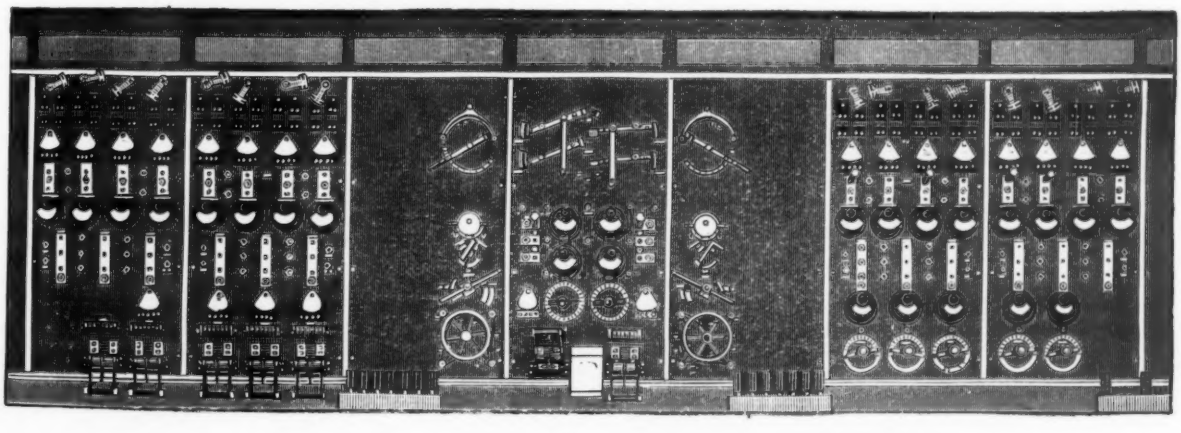
PATENT EXPANSION BOILER FLUE.

as illustrated, provides completely for this, without injuring its efficiency as a stay. The flue is made up of a series of short lengths, as shown, which are composed of fine, soft, and exceedingly tough steel. The plates are bent in such a way as to be, when finished, perfectly cylindrical, thus adding to the strength of the flue. They are then carefully welded. When welded, the ends are heated in a suitable furnace, and enlarged in a powerful flanging machine in such a way that the end of one plate exactly fits within that of the next; the holes are then drilled through both, and riveting completes the work. It will be seen that both the laps, or doubling of the plate at the seam, as well as the rivet heads, are removed from the line of draught, and consequently escape the scouring action and intense heat of the gases as they pass along the flue. Flues made on this principle have withstood severe tests most successfully, and the collapsing strength is about double. The boilers are constructed throughout by skilled workmen, aided by the most modern machinery. The best materials only are used, and all boilers are tested by hydraulic pressure before leaving the works. The steel used is of a special mild quality, very ductile and easy to weld. It is manufactured expressly for Davey, Paxman & Co., and each plate is carefully annealed after having passed through the various machines.

In connection with the boilers, there is a pair of Messrs. Edward Green & Son's improved patent fuel economisers containing 400 heating pipes. This fine pair of economisers are arranged side by side, and the main flue is constructed so that the heat is passed through this battery of economisers on the circuit system. In order as far as possible to economise space, on the outside of each economiser space is left for the removal of the soot deposited by the scrapers, and for examination and repairs.

The feed water is supplied to the economisers cold, and in its passage through the pipes of the economisers is raised to 175° or 180° Fah., so that a very material saving in coal is effected, besides the advantages gained to the boilers by being fed with water at such an increased temperature.

This economiser plant has been constructed upon Messrs. Green's latest principles to meet the requirements of the modern high-pressure steam, and every detail of pipes, also top and bottom boxes, has been very carefully constructed, so as to ensure extreme accuracy of jointing and strength. In this respect it is found of the greatest importance that the friction taper joint should be of the standard pitch, a subject to which Messrs. Green and Son have devoted years of practical study, and from their lengthened and world-wide experience, it is stated as a fact that they can ensure a joint, made on their special taper system—metal and metal—that is invulnerable under the most extreme test that can be put upon it; and this they claim as being a detail of the first importance, ensuring as it does absolute strength, without any unequal expansion or contraction. The excellence of the castings both of the heating pipes, together with the top and bottom water boxes, is the result of the especial mixture and system of moulding adopted by Messrs. Green and Son at their extensive works in Wakefield. The arrangement of this large plant at the Eccleston works was made by Mr. Charles Savage, C.E., Messrs. Green & Son's London representative.



SWITCHBOARD.

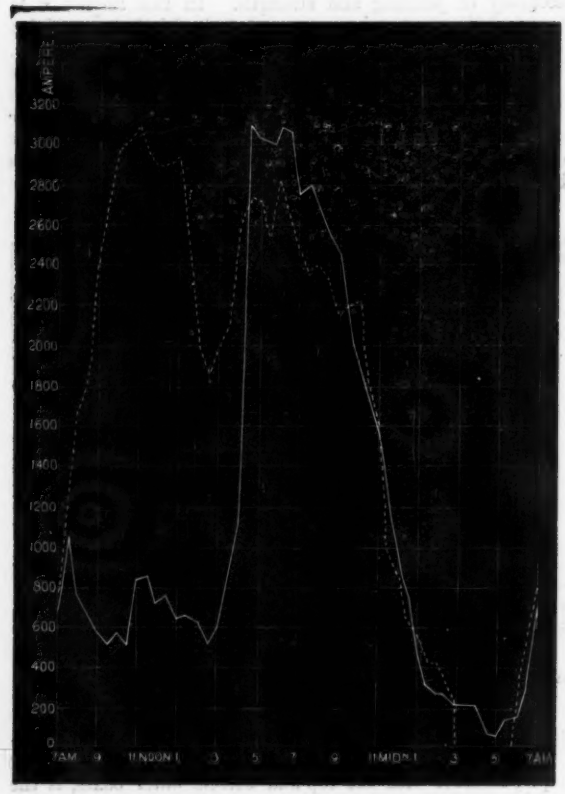
The battery room, which is over the boiler house, contains two batteries, each of 56 cells, Crompton-Howell cells, placed on strong wooden racks. The capacity of each is 500 ampère hours. There are empty racks sufficient to hold a like number when required. The batteries play an important part in the

supply. They are charged in parallel with the circuit during the hours of light load, so as to increase the load at these times. By the evening they are full, and remain standing so until the load has fallen to a point at which they can be allowed to discharge. The engines are then stopped and the station shut down, the batteries taking the load all night. As nearly as possible the full nominal capacity of the cells is charged and discharged every 24 hours. In the summer months, when the demand for light is much less, the whole of the morning load will be run from the batteries.

The switchboard is placed in a gallery, reached at each end by steps. It is made by Crompton, and fitted up for 14 dynamos and 8 feeders. On the negative side of the board is an automatic switch for each dynamo, which, at the time of slowing or stopping, prevents the machine being run as a motor. On the third wire slate is a switch which controls the small dynamo, and which serves to balance the negative or positive side as required. The usual current indicators are used.

Generally speaking, the two outside wires show nearly equal balancing; in fact, it is by no means uncommon to find a perfect balance. The connections at the back of the switchboard are mainly solid copper bars. The switchboard is about 2 feet from the wall, thus making the work of repairing easy.

It is, perhaps, worth while referring to the meter employed for measuring the discharge of the batteries. It is a form of Aron meter which has been designed by Mr. Miller, of Kensington. The pendulum is so modified that the charge or discharge is accurately measured. An electro-magnet is used, which obviates the trouble of a permanent magnet when reversing the current through the meter. When discharging the batteries, the meter would be placed at zero,



December 17th. ——— | December 24th. - - - - -

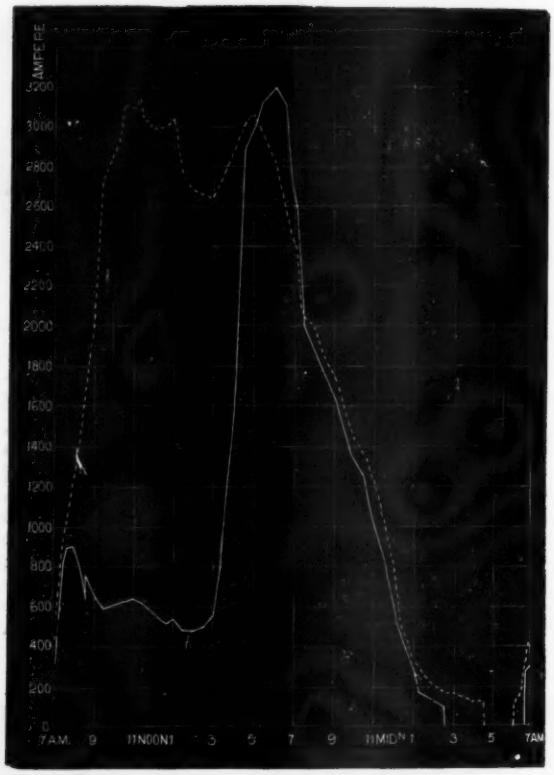
Output diagram, Millbank Street and Eccleston Place Stations (working in parallel) on December 17th and 24th, 1891.

Number of lamps on circuit equivalent to 35,510 of 8-C.P.

and the current passing through the meter would indicate the number of ampère hours. The batteries would then be charged until the meter indicated zero, when the same amount of current taken out would have been put back.

The dynamo leads are put in 3-inch gaspipes, and the gas-pipes have been built into the wall and flooring. This is an exceedingly neat arrangement, and puts out of sight otherwise ugly wires. Spare pipes have been left for any new cables.

There are connected to this station 24,052 8-C.P. lamps. The working capacity of the station is nominally about 3,000 ampères. The maximum load at the station is in the evening about 2,000 ampères, 400 ampères usually going out during the day. There is a somewhat heavy load in the early morning, usually about 800 ampères, which lasts until daylight. We are enabled, by the courtesy of Prof. Kennedy, to publish the typical load curves of the stations.



December 17th. ——— December 24th. - - - - - -

Output diagram for Davies Street Station on December 17th and 24th, 1891.

Number of lamps on circuit equivalent to 27,460 of 8-C.P.

The diagrams refer to two days in December, the dotted line representing an exceptionally foggy day, the other approaching more nearly to an ordinary winter's day service. The diagram for Eccleston Place cannot be accurately separated from that for Millbank Street, because the two stations work in parallel. Davies Street station is not yet in parallel with the others, but will be changed over in a few months to the 3-wire system. The great suddenness of the fall in the Davies Street diagram after 7 p.m. is accounted for by a large number of shops then ceasing to take current.

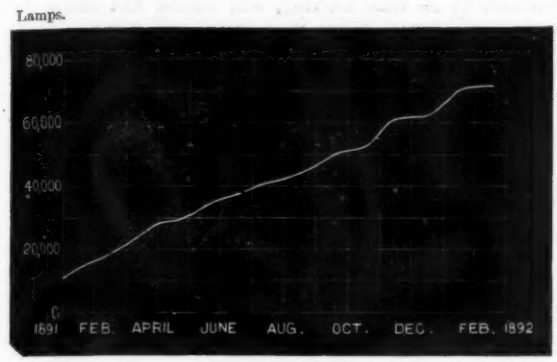
As showing the exigencies which these stations are sometimes called upon to meet, it is interesting to mention that during a sudden snowstorm last week the load was suddenly multiplied five times in ten minutes, rising from 1,000 ampères to 5,300. The boilers were, however, equal to the emergency, and the pressure did not fall. The batteries were, however, discharging freely for a minnte or two before the engines were got to work, an occurrence which has never happened at anything like heavy load, and a condition which obviously could only last for a very short time indeed.

The mains, for the most part, consist of Kennedy's system of copper strips resting on insulators, in culverts when there is room for them under the pavements.

At Eccleston Place everything has been done which can improve the efficiency of the station. Meanwhile the appearance and the arrangements generally are not neglected, and we have a bright, well-lighted building which must

surely do credit to English central stations. Mess rooms are provided for the men, and many other conveniencies have been introduced which hitherto have received little attention in these kinds of buildings.

Commercial considerations of an electric lighting company are difficult. Comparisons rarely affect the question. Each company must be judged solely on the conditions which surround its work. We cannot, at this early stage, make any remarks on the profits which may arise from the undertaking. We can, however, draw attention to the enormous



TWELVE MONTHS LAMP CONNECTIONS.

increase in the company's business, which is shown in a curve illustrating the lamp connections of the company for the past twelve months.

Our thanks are due to Prof. Kennedy and Mr. Grimshaw, the resident engineer at Eccleston Place, for their kindness in helping us to give information concerning the work of the Westminster Electric Light Corporation.

NOTES.

New Telephone Cable.—The *Elektrotechnische Zeitschrift* understands that Messrs. Siemens and Halske have succeeded in producing a new telephone cable which the Bavarian telegraph authorities consider as an important advance for the introduction of the double wire system. The cable, which as far as our contemporary learns, is made in a similar manner to the Fortin-Hermann cable, is of low capacity and is suitable for long distance telephony.

Caution.—The Exchange Telegraph Company cautions the public against the attempts of various persons to obtain access to City offices on the pretext of being inspectors of the company's instruments. Each employee of the company, we are informed, is provided with a pass card, and subscribers are requested to ask for its production in the event of strangers wishing to inspect the instruments.

Interruption of Electric Light and Telephone Service by Fire.—On Thursday last week, a fire occurred in a railway arch under the South Eastern Railway in Rotherhithe New Road, on the premises of some varnish makers. The fire which was exceedingly fierce attacked a portion of the railway property, the telephone wires on the railway, and the trunk mains of the London Electric Supply Corporation, which are affixed to the parapet of the railway, causing interruption to the telephone communication between London and Paris, and to the service of the Electric Supply Corporation. Large gangs of men belonging to the various companies were at once set to work, and the telephone communications were restored by ten o'clock the same night, the service of the London Electric Supply Corporation being restored about an hour later. Major C. B. Waller, of the London Electric Supply Corporation, Limited, has written to the *Times* in order to prevent misapprehension on the part of a considerable body of the public who were inconvenienced by the interruption in the service of the company. The damage done was not to the premises of the Electric Supply Corporation which are nowhere near to the scene of the fire, but to the mains running from Deptford to London.

Portuguese Telegraph Rates.—A *Financial Times* correspondent at Lisbon, telegraphs that in consequence of the present rate of exchange, the rates for International telegrams from Portugal will be raised 20 per cent.

Amalgamation of the National and the Sheffield Telephone Companies.—A transaction of considerable interest and importance to the business and general community of Sheffield was completed last week says the *Sheffield Independent*. For some time negotiations have been going on between the National Telephone Company, Limited, and the Sheffield Telephone Exchange and Electric Light Company, Limited, with a view to the acquisition of the latter by the former. These negotiations were completed on Tuesday last by the signature of an agreement, which received the sanction of the respective boards of directors on Thursday. The competition of the two companies has caused the rate for telephonic communication in Sheffield to be exceptionally low; but we understand the directors of the amalgamated undertaking intend to approach the question of price in a very conciliatory spirit.

Fires and Injuries Caused by Electric Currents during the Year 1890.—In a report read by Mr. Allen R. Foote at the Buffalo Convention, to which we referred last week, some very interesting statistics are given of the fires and injuries caused by electric currents during the year 1890. The statistics were obtained from 425 cities in the United States and are as follows:—

Total number of fires caused by electric currents	518
Total number of injuries received while on duty	1,719
Total number of injuries received while on duty at fires caused by electric currents	35
Total number of injuries caused by electric currents to men while on duty	31
Total number of fatal injuries received while on duty ...	60
Total number of fatal injuries caused by electric currents to men while on duty	1

In some remarks following the reading of the above data it was shown, says the New York *Electrical World*, that in the single case of a fatal injury caused by electric currents to an attendant while on duty, a man fell from a pole thirty-five feet high, and as there was no autopsy, it could not be learned what the exact cause of death had been.

The Work of a Life-Time.—The following appeared in the columns of our contemporary, the *Engineer*, last week:—

"Wanted by a gentleman, a few lessons in general engineering. Instruction to be taken in the evenings only.—State terms &c., &c., to P874, *Engineer* Office, 33, Norfolk Street, Strand, W.C.

From this we suppose that the "gentleman" wishes to become proficient in all the different classes of engineering, including of course, electro-technics. We wish him every success in his studies, but we feel sorry that he has only his evenings to devote to his task; he would have been better able to accomplish what he wishes, could he have worked on uninterruptedly for twenty or thirty years or more. We are anxious to know whether he has secured an instructor, and the terms agreed upon.

Accumulator Cars in Rome.—It is stated that the Omnibus and Tramway Company of Rome, has recently made experiments with an accumulator car fitted with motors, batteries, &c., supplied by the Oerlikon Engineering Works. When fully charged, the cells are said to be capable of yielding energy to propel the car 93 miles, so that it is only necessary to recharge every alternate day. At the trial, the car attained a speed of 18·6 miles an hour, but the normal speed of the cars which it is proposed to introduce when permission is obtained, will only be 7½ miles an hour.

Electric Lighting at Worcester.—At a meeting of the Worcester Watch Committee held last week, the Town Clerk presented the report of Mr. Preece, who had been consulted by the committee for the consideration of the tenders for supplying electric light to the city. It stated that fifteen tenders had been sent in from first-class firms, who had submitted very complete and practical plans. It was resolved to adopt the report, and to recommend the Council to accept the tender of the Brush Engineering Company for lighting the city by electricity. The tender was £20,030. It was stated hat the annual working expenses were estimated at £3,150.

The Electric Light at Taunton.—The "burning" question at Taunton at the present time is that of the desirability or otherwise, of purchasing the electric light works in that town. In December last, the council had before it a proposal to enter into negotiations with a view of buying both the gas and electric light works, but after communications had passed between the parties concerned, it was found that the sum required for the former was more than the council felt justified in giving. The idea of purchasing the gas works was therefore abandoned, but the directors of the electric lighting company asked a price which was regarded as one which the council might entertain; and the question is to be considered at a special meeting of the municipal body, to be held on the 22nd inst.

Islington Electric Light Company, Limited.—The *Financial News* says:—"The electric lighting business is showing some signs of revival. We learn that the Islington Electric Light Company, Limited, is being formed, with a capital of £250,000, and will be offered shortly to the public. Sir Frederick Abel has been invited to join the board, and the enterprise is said to have secured influential support."

"Old America" at Manchester.—A company has been formed for the exhibition of a representation of "Old America," during the coming summer, in connection with the Botanical Gardens—where it will be remembered the Exhibition of 1887 was held. The model of the Eddystone Lighthouse at the late Naval Exhibition is to be re-erected in the grounds, and will again be fitted with the powerful electric light. All the streets in "Old America," and the promenades in the gardens, will be illuminated by electricity, while at the chief entrance a representation of the "Liberty," statue, holding a powerful electric lamp, will be erected. Altogether the representation of "Old America," together with the well-known gardens, promises to offer a charming resort to Manchester people during the coming summer evenings.

Made in England!—We have referred on many occasions to bogus electrical novelties, so that we think it unnecessary to lengthily discuss the merits of every counterfeit invention which comes before us, but we feel it impossible to forbear noticing one of these public blessings which has been brought before us by an Indian correspondent. "A great advantage for examinees!!!" heads the supplier's advertisement appearing in an Indian paper, and he proceeds to describe an "electric penholder," which is said to be manufactured in England. The pen is said to have a battery set at the point where the writer holds it, and by the use of this a "candidate for examination becomes undaunted." "It sharpens the memory, prevents the shivering of the hand, and enables him to write quickly." It also has the marvellous effect of curing short-sightedness. Our correspondent suggests that this may perhaps be of interest to a renowned medical electrician in England.

Facilities for Posting Telegrams.—The following notice has been issued by the Postmaster-General:—"It is believed that the public are not generally aware of the fact that telegrams which cannot be conveniently handed in at a telegraph office may be posted in a wall or pillar box, or at any post office which is not a telegraph office. Telegrams so posted are sent on by the next collection to the telegraph office to which the letters included in such collection are taken, and are thence transmitted free of extra charge, provided the proper amount has been prepaid by means of postage stamps. It should, however, be understood that telegrams so posted cannot, as a rule, reach their destination so expeditiously as those handed in at a telegraph office. Care should be taken to write legibly and to give a correct and sufficient address. The sender should also write his name and address on the back of the form in case of miscarriage. It is desirable, although not absolutely necessary, to enclose the telegram in an envelope marked 'Telegram, immediate.' An ordinary telegram form, with stamps of the requisite value affixed, may be used; but persons likely to post telegrams in any considerable number will find it convenient to provide themselves with a supply of forms already embossed with stamps, which may be purchased singly, price 6d. each. In case of necessity the telegram may be written on a piece of plain paper."

Telegraphs in Canada.—A proposal has been made to the Dominion Government with the view of it taking over the control of all the telegraphs in the country as in England. Mr. F. N. Gisborne, the superintendent of the Government telegraphs, has drawn up a report on the subject.

Cardiff Electric Lighting.—Last week the Cardiff Electrical Committee visited London for the twofold purpose of interviewing some prominent electricians and inspecting some of the installations in the City. The Cardiff County Council, at its next meeting, will receive and adopt the committee's report, which, it is stated, will recommend the immediate introduction of the electric light as a public illuminant in the town.

The Royal Society.—The following papers were announced to be read yesterday afternoon:—Dr. Hopkinson, F.R.S., and E. Wilson, "Dynamo-electric Machinery." R. T. Glazebrook, F.R.S., and S. Skinner, "On the Clark Cell as a Standard of Electromotive Force."

Delays on the City and South London Railway.—Another breakdown occurred on the Electric Railway last Monday morning, the passengers being delayed for about 20 minutes. The cause was an accident to the engine between the Elephant and Castle and Borough Stations.

Sky-Signs.—On Monday last, Messrs. Carwardine & Co., millers, in City road, were summoned by the County Council before the magistrate at Worship Street for erecting a sky-sign without a license. The structure to which objection was taken is a windmill above the defendants' premises, which works a dynamo for the production of the electric light, grinds corn, and performs other useful services. Round the platform of the mill is a fence formed of the letters of the defendants' name, and these letters are necessarily open to the sky because of the force of the wind. Mr. Rose, the magistrate, decided that the erection in question was not a sky-sign within the meaning of the Act, and therefore dismissed the summons. A notice of appeal was given.

Electricity in the Silk and Ribbon Industries.—The City Council of St. Etienne has decided upon a departure which will have an important effect on the silk and ribbon industries both in Europe and in America. It has been resolved to apply electric motive power to all the handlooms in the city, and contracts have been made with an electric company for the necessary plant and supply. The number of looms is 18,000.

The Poolite Musical Society.—Successful in every sense of the word was the first smoking concert given under the auspices of the above society, in the dining saloon, Broad Street Station, on Tuesday evening, the 8th inst., at which about 200 of the employés and friends of Messrs. Poole and White, Limited, assembled. At the conclusion a hearty vote of thanks was passed to the chairman, Mr. Wm. White, for presiding, to which, in replying, he referred to Mr. A. A. King, the promoter of the Society, to whom great credit was due for the successful manner in which the concert was carried out.

Manchester Technical School.—A special course of two lectures and four demonstrations for electrical engineers, electric bell and telephone fitters, plumbers, &c., are being given at this School, on "Wiring, for Electric Light and other Purposes." The first of these lectures took place last Saturday, titled, "Insulation, and Methods of Testing," by Mr. W. W. Haldane Gee, B.Sc. The next lecture will be given on April 2nd, by Mr. S. Joyce, A.I.E.E., on "Rules for Wiring." The demonstrations will be on March 12th, 19th, and 26th, and April 2nd.

Football.—Silvertown v. Siemens Bros.—The return match between the staffs of these two firms was played in Charlton Park on March 12th, and resulted in a win for Siemens Bros. by two goals and a try (11 points) to nil. By the kind invitation of Mr. Siemens both teams dined in the evening at the Holborn Restaurant, when a very pleasant evening was spent.

Personal.—We hear that Major-General Alexander H. Elliot, C.B., and Captain H. F. Twynam have joined the Board of the European Sims Edison Electrical Torpedo Company, Limited.

Pontypridd Lighting.—At last Friday's meeting of the Pontypridd Local Board the subject of lighting the town by electricity was again brought forward. It was decided, however, to adjourn the consideration of the matter pending the result of the negotiations for the purchase of the gas-works.

Colliery Electric Light.—We hear that the Glasgow Iron and Steel Company, Limited, by way of experiment, have introduced the electric light on the surface at Camp Colliery, and in the event of it being a success, they intend introducing it at their other works.

The London Telephone Service.—We have received from the Pioneer Telephone Company, Limited, a circular headed, "Improved Service for London! Large Reduction in Telephone Rates," which reads as follows:—"Telephone users are informed that the New Telephone Company will shortly commence operations, and that their rates will be little more than half of those now charged in London for the existing services. The New Telephone Company's system will have twin wires, ensuring clearness of speech, freedom from all disturbing noises, and absolute privacy. It will be fitted with the newest switching apparatus whereby rapidity in connecting and disconnecting will be greatly facilitated. The twin-wire system is already in full operation in Manchester, where the Mutual Telephone Company has nearly 1,000 subscribers on their exchange, although it has only been in operation for about a year. A representative of the New Telephone Company will shortly have the pleasure of waiting upon you to explain the advantages of the company's system."

Crystal Palace Electrical Exhibition.—The following gentlemen have consented to serve on the Jury for this Exhibition:—Prof. W. Grylls Adams, D.Sc., F.R.S.; Prof. W. E. Ayrton, F.R.S.; Mr. Shelford Bidwell, M.A., F.R.S.; Mr. Conrad Cooke, M.Inst.E.E.; Prof. W. Crookes, F.R.S.; Mr. W. B. Esson, M.Inst.E.E.; Major-General Festing, R.E., F.R.S.; Prof. George Forbes, M.A., F.R.S.; Captain Sir Douglas Galton, K.C.B., D.C.L. F.R.S.; Dr. J. H. Gladstone, F.R.S.; Mr. J. H. Greathead, M.Inst.C.E.; Mr. Charles Hall, M.Inst. E.E.; Prof. D. E. Hughes, F.R.S.; Sir Henry Mance, C.I.E.; Mr. W. H. Massey, M.Inst.C.E.; Mr. W. H. Preece, F.R.S.; Mr. A. Reckenzaun; Prof. Henry Robinson, M.Inst.C.E.; Captain Sankey, R.E., M.Inst.E.E.: Mr. C. E. P. Spagnoletti, M.Inst.C.E.; Mr. James Swinburne, M.Inst.E.E.; Prof. Silvanus Thompson, D.Sc., F.R.S.; Mr. J. Tomlinson, M.Inst.C.E.; Prof. W. C. Unwin, B.Sc., M.Inst.C.E.; Major-General Webber, C.B., R.E.; Mr. J. W. Wilson, M.Inst.C.E.

Crystal Palace.—In connection with the Electrical Exhibition a smoking concert has been arranged for Friday next (March 25th), to be held in the Grand Saloon, under the presidency of Henshaw Russell, Esq. The balance from the sale of tickets (1s. each) will be handed over to the Norwood Cottage Hospital. The hon. secretary is Mr. A. E. Harris (Messrs. Rashleigh Phipps and Dawson), Stand 101.

Volk's Electric Railway.—The Works Committee of the Brighton Town Council have had under consideration a plan showing the present line of Volk's electric railway on the Madeira Road, and the proposed diversion from the Royal Crescent Groyne, south of the enclosures. In accordance with instructions, the surveyor had seen Mr. Volk, who had agreed to the proposed diversion, and asked consent to erect a station at the south east end of the eastern enclosure, as shown on the plan submitted for the Committee's consideration. It was resolved that the proposed diversion be approved subject to Mr. Volk, with an approved surety, entering into a new agreement with the Corporation for permission to continue the railway on the beach, and as to the terms and conditions on which the same should in future be issued.

O. S. A.—A smoking concert will be held at Mason's Hall Tavern on Friday next, March 25th, at half-past seven.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Anglo-American Telegraph Company, Limited.—The annual return of the above, made up to February 12th, 1892, was filed on the 11th inst. The nominal capital is £7,000,000 stock, all of which is fully paid. Registered office, 26, Old Broad Street, London, E.C.

Gülcher (New) Electric Light and Power Company, Limited.—The annual return of this company, made up to December 31st, 1891, was filed on the 9th inst. The nominal capital is £70,000, divided into 50,000 preference and 20,000 deferred shares of £1 each. All of these have been taken up, and the deferred shares have been issued as fully paid. Upon 12,277 of the preference shares the full amount has been called, and upon the remaining 37,723 10s. per share has been called. The calls paid amount to £36,650 1s. 4d., and unpaid to £175 18s. 8d. Registered office, Battersea Foundry, London, S.W.

Brompton Electric Fittings Company, Limited.—The second annual return of this company, made up to December 21st, 1891, was filed on March 2nd, 1892. The nominal capital is £2,000 in £1 shares, of which 1,050 have been taken up, the full amount called and all calls paid. Registered office, 146, Brompton Road, S.W.

British Electric Installation Contractors, Limited.—The statutory return of the above-named company, made up to the 25th ult., was filed on the 1st inst. The nominal capital is £20,000 in £5 shares, of which 242 have been taken up. Of these 100 have been issued as fully paid, and the full amount has been called on the remaining 142, resulting in the payment of £575, and leaving £135 unpaid. Registered office, 1, Angel Street, Worcester.

Devon and Cornwall Electricity Supply Company, Limited.—In reply to enquiries respecting the working of this company, a letter has been received from G. W. Murray, of Plymouth, to the effect that the Board of Trade had revoked their provisional order. The 42 shares held by the seven shareholders (who were also directors) had been forfeited, therefore there were no shareholders and no assets, and there was nothing remaining but a voluntary winding up. No office has been filed.

Chloride Electrical Storage Syndicate, Limited.—The registered office of the above-named company is situate at 13 and 14, Abchurch Lane, London, E.C. (Filed on the 20th ult.)

Newcastle and District Electric Lighting Company, Limited.—The annual return of this company, made up to the 29th ult., was filed on the 9th inst. The nominal capital is £50,000, in £10 shares, of which 3,075 have been taken up. Upon 2,138 of these, £8 per share has been called, upon 430 shares £6 per share has been called, and upon the remaining 507 shares £4 per share has been called. The calls paid have realised £21,694, leaving £18 unpaid. Registered office, 38, Grainger Street West, Newcastle-upon-Tyne.

BUSINESS NOTICES, &c.

Catalogues.—Messrs. Nalder Brothers & Co., of Clerkenwell, have recently issued some new price lists. Their electrical testing and other scientific instruments are beautifully illustrated, and very minute information as to prices of the different articles are given. Attention is specially drawn to batteries and standard cells, condensers, electrometers, galvanometers and keys, and, in addition to these, separate particulars are given of their miscellaneous manufactures. Messrs. Nalder include also prices, as well as very clear illustrations of apparatus and instruments described and referred to in Prof. W. E. Ayrton's "Practical Electricity." Another price list has also been issued, giving full details of the ammeters and voltmeters and resistance frames, &c., manufactured by the firm. We do not doubt that these catalogues will be of great use to Messrs. Nalder's customers, and also to users generally.

New lists have recently been issued by Messrs. W. T. Goolden and Co. of their dynamos and motors, and also of their voltmeters and ammeters for direct and alternate current service.

Very full information and clear illustrations are given of the different types of dynamos, engines, pumps and motors manufactured by the firm.

Electrician's Watch.—A new watch has come to the front, which will soon be commanding the attention of the electrical world. Messrs. Stauffer, Son & Co., of 13, Charterhouse Street, London, E.C., seem to have fully realised the present wants of all concerned, as they are now producing a new watch with lever *anti-magnetic* escapement, compensated balance, adjusted to isochronism, temperature, and position, each one passing the severe test of the Kew Observatory, and which can be retailed at the prices of ordinary watches. It must naturally be a perfect timekeeper to be able to stand the rigid test of the Kew Observatory, and as regards its anti-magnetic properties, it can be best realised from the report by the Kew Observatory, dated January, 1892:—"We have tested your non-magnetic watch, and find it apparently *quite unaffected* by being placed in a magnetic field *of great intensity*." Another important feature of this new watch is the addition, at a small extra outlay, of an improved and newly invented system of chronograph work with minute recorder.

The Electric Light in the City.—We learn that several further installations are at present being carried out in the city. Messrs. B. Verity & Sons, of Covent Garden, are fitting up an installation in the premises of Sir John Bennett, Limited, in Cheapside, where structural alterations are in course of completion. Mr. John O. Grant, of 63, Finsbury Pavement, is fitting up the premises of Messrs. Reeves & Sons, Limited, 113, Cheapside. Messrs. Croggon and Co., of Upper Thames Street, are fitting the electric light in the offices of the River Plate Trust Loan and Agency, Limited, 61, Moorgate Street, while Messrs. Laing, Wharton & Down, of New Bond Street, are carrying out a contract in the offices of Messrs. Vivian, Young and Bird, Leadenhall Street.

General Electric Power and Traction Company, Limited.—In the lists issued by this company of their electric mining plant for pumping, hauling, lighting, ventilating, rock drilling, coal cutting, &c., special prominence is given to electrical transmission of power in mining work. Illustrations appear of the company's combined engine and dynamo plant as well as the "Immisch" mining dynamo, compound wound dynamos and fans and motors. A number of testimonials are included, and there is also a plan of pumping and hauling arrangements in St. John's colliery, Normanton. Some new loose lists also illustrate the same machinery and state full particulars regarding the prices. The information cannot fail to be very useful to those interested.

Tenders for Electric Lighting.—The committee of the Railway Clearing-house are prepared to receive tenders for wiring and fittings for electrically lighting the two blocks of buildings situate in Seymour-street, Euston-square, London, known as the Railway Clearing-house. Specifications, schedules, and plans may be obtained on application to the secretary, on payment of 21s. Tenders are to be delivered at the office of Mr. H. Smart, secretary to the committee, the Railway Clearing-house, Seymour-street, Euston-square, before 11 o'clock on Wednesday, March 30th.

Tenders Wanted.—Germany.—The authorities of the town of Mähr-Ostrau, situated in the Mähr. Silesian coal and iron districts, are inviting tenders until the 30th April, for the erection of a central station to supply current for the working of an electrical tramway, 4¾ miles long, between Mähr-Ostrau, Privoz and Witkowitz, and for the lighting of about 260 arc and 3,700 incandescent lamps in these towns. Tenders are to be addressed to the Stadt-Vorstande, Mähr-Ostrau.

Change of Address.—We are requested to state that the Metropolitan Electric Supply Corporation, Limited, are about to remove to new offices adjoining the company's Manchester Square Station, and in their own district. All communications therefore, after the 18th inst., should be addressed to 17, Manchester Square, W.

Mr. Robert G. Ivey has removed his business from 22A, Chatham Place, Hackney, and has taken larger premises with steam-power at 7, Portpool Lane, E.C., where there is every facility for carrying out every description of electrical work.

Dorman and Smith.—Messrs. Dorman and Smith, of Manchester, have moved into their new premises, to be known as Ordsal Station Electrical Works, Salford. The offices formerly occupied by the firm at Brazenose Street and the factory in Hulme Street are now vacated. In a circular just issued, Messrs. Dorman and Smith express their belief that they have now the largest and most completely equipped factories for the exclusive production of electric light accessories in Great Britain.

The Electric Light in the West End.—An installation of the electric light is at present being made at No. 8, Adelphi Terrace, W.C. The work is being carried out by the electrical department, of Mr. William Whiteley, "the World's provider," at Bayswater. Messrs. D. Hulett & Co., Limited, of High Holborn, are fitting up an installation in the Mogul Hotel, adjoining the Middlesex Music Hall, in Drury Lane, W.C.

The Electric Light in the Strand District.—Messrs. Watson Gisenheiner & Co., electrical engineers, of Glasshouse Street, W., are fitting up an installation of the electric light in some new buildings—Talbot House and Clock House, in Arundel Street, Strand.

Electrical Interlocking.—An interesting announcement appears amongst our advertisements regarding Messrs. Saxby and Farmer's system of electrical interlocking in its application to ordinary block working.

The Electric Light in the West End.—Referring to our notice of last week, in which we stated that the premises of the Bodega Company, Limited, in Bedford Street, Strand, are being fitted up by The Electric "Supply" and Fittings Company, we find that this work is being carried out by the The Electric "Wiring" and Fittings Company, Limited, of 42, Duke Street, St. James's, S.W.

Browett, Lindley & Co.—Messrs. Browett, Lindley and Co. have removed from Sandon Works, Salford, to Patricroft, Manchester.

CITY NOTES.

Kensington and Knightsbridge Electric Lighting Company, Limited.

THE fifth ordinary general meeting of this company was held on Thursday, 10th inst., at Great George Street, Westminster, Mr. GRANVILLE R. RYDER presiding.

The SECRETARY (Mr. W. R. Erskine) having read the notice convening the meeting, also the minutes of the previous meeting,

The CHAIRMAN stated that it would be seen that the company had made very substantial progress during the year; that they had jumped from 25,535 lamps to 38,408, an increase of 12,873, and that they had increased the number of houses and shops lighted from 291 to 436 on December 31st, 1891, an increase of 145. With regard to the accounts they would observe that during the year there had been an increase in the capital account of £21,780, which had been laid out in this way:—In mains and improvements to same, £8,000; plant, £7,500; batteries, £4,200; instruments and meters, £1,200, and in buildings £1,000. With regard to the renewal fund that stood last year at £1,398 odd, and had been increased this year to £1,713 odd. A satisfactory feature in the accounts was that the production of electricity which last year cost £2,915, had only cost £4,067 this year; and whereas last year, with nearly £3,000 spent on its production, it only produced a profit of £1,404 odd, this year, with only an increase of about £1,000 in production, they had increased their profits to £4,381 17s. 9d. Therefore the increase in cost of one-fourth, had increased their profit by two-thirds. He thought they might fairly say, that taking the accounts generally, they were satisfactory. They could have wished for more business, that was the only point upon which they were disappointed. They expected to get up to 40,000 lamps this year, but they had only reached 38,400. Since they had reached the latter figure the number of lamps had increased by about 1,000, but still they had not reached 40,000. From the figures it would be seen that a large proportion of profits might be expected from the company's business in the future. This was further exemplified by figures which the secretary had worked out for him, showing the cost of the unit for which they charged 8d. He had worked it out for this year and found that the actual cost was 5½d. out of the 8d., leaving a profit of 2½d.; whereas last year the cost was 6¼d. out of the 8d.; therefore they had gained one penny per unit as compared with the preceding year. There was another point he would mention, it was with regard to the amount of gross revenue to be derived from each lamp. Last year he was able to put it at 10s. for the year preceding the last meeting, but they found now that it was not so much as that, being not more than 9s. per lamp. It was difficult to say what the cause might be. He thought it was possible that the public were getting more used to the electric light and knew better how to treat it and began to think that it was more economical. He did not think they need to be dissatisfied with the result because, after all, everything that tended to cheapen the electric light was for their interests although they did not get so much profit out of it at first. With regard to the capital account, of course, it was the object of the directors to keep that down as much as possible, but at the same time it was impossible for a company of their kind to progress without constantly getting fresh capital. The great point was not to get more capital than they could see an advantageous way of using and getting a profit out of. As far as the year 1892 was concerned it was not likely that they would want more than £14,000 or £16,000 to carry out some extension of mains and probably to provide new plant at both their stations, but that would not be to a very great extent. He then formally moved that the report and accounts be adopted and entered upon the minutes.

Mr. G. H. HOPKINSON seconded the resolution.

A Shareholder, after referring to the peculiar way in which the accounts had been got out, said that it seemed to him they were in an unfortunate state of affairs; in the memorandum that Mr. Crompton (their engineer) drew out, he said that there would be upwards of 33¼ per cent. divisible amongst the shareholders. Of course they never for a moment believed that they were going to get that profit, but he thought they might have received one-fourth. They had been at work for several years and had only a dividend of two per cent. Personally he did not care so much about it, but some friends of his had taken shares in the concern because he did himself. It certainly had been a most unfortunate concern, and it appeared that there was very little hope for the future. They kept on raising capital, and that had to take the same course as the other capital. He would suggest in future that the accounts be made out in a more intelligible manner, and wherever economies could be introduced they should be. He asked how the amounts of £886 for salaries, and £686 for law charges, &c., were made up.

Referring to the last speaker another shareholder asked under what head the directors' fees came.

It was suggested that the number of units sold should be given. A question was asked regarding the Lane-Fox action then going on.

The CHAIRMAN replying to questions asked, said that he quite agreed with the suggestion of stating the number of units sold, and they would have it done in future. With regard to the form of accounts, this was the same as drawn out by their auditors. Referring to the question of the 9s., he thought that was worked out by Mr. Erskine to an average of about 30,000. He did not see how they could expect to jump into dividends at once. It had been no doubt somewhat slow in their district, but this year it had made a very great advance; almost all the large shops in Brompton Road were using the electric light, and every day fresh orders were coming in. Regarding the question of the directors' remuneration, as a matter of fact they had not taken any fees, and the salaries he did not think were at all high; they had two stations and a staff which, was more or less scientific, which must be paid, and he thought £886 to keep that staff going was by no means a large amount. Regarding the law charges, there was a considerable increase, because they were obliged to petition against one or two bills in Parliament by the London County Council, and he thought that increased it £300.

The motion was then adopted.

The CHAIRMAN next moved that a dividend at the rate of 2 per cent. per annum to December 31st, 1891, be paid on or after March 31st next.

Mr. R. W. WALLACE seconded the resolution which was carried unanimously. He stated that in the action of Lane-Fox *v.* their company, if they should lose the case the cost would not all be borne by their company as there were several other companies connected with the action.

Mr. SCHWANN next moved that Mr. A. S. Bolton be re-elected director of the company. Mr. Saunders seconded this motion which was carried.

It was next resolved unanimously that Sir Frederick Bramwell Bart., F.R.S., be re-elected director of the company.

Sir FREDERICK BRAMWELL said that in returning thanks he had an opportunity of saying a few words. Referring to the amount of their salaries he wished the shareholder who asked the question and the others if they agreed with his views to understand that the business they were pursuing was one of great difficulty requiring the very greatest care and attention. They must remember that if they had their lights go out or in any way fail even for a short time it would do much to discourage the increase of electric lighting in their district. It was therefore necessary that they should have a thoroughly efficient staff; he considered that even now the salaries were wholly inadequate and it was really nothing more than the desire of the employees to stand by the company that kept them there. The item would appear larger next year. The consulting engineer's salary was also included in that amount, and after that there remained for the rest of their staff a very small sum in proportion to their services. He, personally, as one of the directors was quite content to go without fees until the company could afford to pay them, but he was not in favour of paying the men inadequately.

The auditors Messrs. Lovelock, H. W. Whiffen and Dickenson were re-elected auditors of the company at a remuneration of 30 guineas per annum.

Mr. SCHWANN proposed a vote of thanks to the directors for their able services in the management of the company, and to the chairman for his services in the chair.

This having been briefly acknowledged by the chairman the proceedings terminated.

The Gülcher (New) Electric Light and Power Company.

THE directors' report for the twelve months ending June 30th, 1891, states that the directors have postponed the presentation of the report and accounts until now, in order that the Chairman might be able not only to interpolate such of the New Zealand accounts as are properly chargeable to the current year, but also to explain to the shareholders at their annual meeting the results of his journey to the colony. It will be seen by the balance sheet that the public lighting installation at Wellington (which was completed early in 1890) had cost the company £13,486 13s. 3d. to erect. This installation, which was producing a revenue of £1,750 per annum, reducible in three years to £1,600 per annum, was costing the company nearly £1,300 per annum to maintain; and, as was pointed out in the last report, the commercial success of the undertaking depended entirely upon the provision of further capital for the supply of light to private consumers. A syndicate which had then already been formed for this purpose, and to take over the public lighting business of the company in the colony, stipulated that Parliamentary powers from the New Zealand Legislature should be first obtained at the expense of this Company. The corporation of Wellington had also set up a claim to be paid a sum, amounting to about £530 per annum, for water, which they alleged that the company used in excess of the quantity which the corporation had contracted to supply, and serious litigation appeared to be imminent. Under the circumstances, it was resolved that the chairman should go to New Zealand, at the joint expense of the syndicate and the company, to settle if possible the disputes with the corporation, and to apply for the necessary Parliamentary powers to enable the company to sell its installation and the benefit of its contract to the syndicate. His journey, although protracted far beyond anticipation, has been completely successful. The dispute with the corporation has been satisfactorily arranged; Acts of Parliament, not only for Wellington but for Christchurch and Auckland, have been obtained; and the corporation have assented to the sale by the company of the Wellington public lighting installation to the syndicate. Could the proceeds of this sale be properly brought into the present year's accounts, the balance sheet would show a profit of £3,000, or thereabouts, instead of a loss of nearly £1,200. The Acts, however, were not obtained until the end of September, and the final arrangements with the corporation were not arrived at until November 26th, 1891, so that the beneficial results of the chairman's journey cannot appear until the next balance sheet is issued. The particulars of the contracts entered into, and of the arrangements made with the corporation of Wellington, will be supplied at the general meeting, when a detailed profit and loss account will also be submitted to the shareholders. With regard to the loss shown upon the year's trading, this is distinctly traceable to the depression which fell upon business in England in the last three months of 1890 and the first six months of 1891, in consequence of the financial crisis in the City. For the first time during the last nine years the year's receipts from sales in England have decreased, and during the nine months above referred to they decreased to £2,500, while the business in New Zealand was temporarily at an enforced standstill. Since then the sales in England have again improved, and a new field has been opened in the colony, which promises to be a large and permanent customer of the company. An agency was also opened in Italy last autumn, and the City of Genoa is already partly lighted by the company. This agency also promises to prove an increasing business. Since the last general meeting the directors, under the powers conferred on them by the articles of association, have elected Captain W. S. Levett, a duly qualified shareholder, to a seat on the board. Mr. Grèwing and Captain Levett retire by rotation from the board, but being eligible, offer themselves for re-election. Mr. Russell Day, the auditor appointed at the last general meeting, also retires, but offers himself for re-election.

The Direct Spanish Telegraph Company, Limited.

THE directors' report for the half-year ended December 31st, 1891, states that the accounts for the half-year ended December 31st, 1891, show, after providing for debenture interest, a balance to the credit of profit and loss of £5,028 12s. 11d. The traffic receipts show a decrease of £2,214 4s. 9d. as compared with those for the corresponding period of 1890. The falling off in the receipts is chiefly due to the reductions of rates which the company had to submit to at the International Telegraph Conference held at Paris in 1890, and which came into force on July 1st last. The working expenses are £17 4s. 5d. in excess of those for the corresponding period of last year. The company's cables, and the land lines in connection with them, have, with one exception, continued in good working order throughout the half-year; a serious fault having suddenly developed, on October 23rd, in the Falmouth-Bilbao cable. The cable was repaired by the Eastern Telegraph Company's cable ship *John Pender* on November 27th, since which date the cable has worked well. The prevalence of bad weather, and the quantity of new cable inserted, brought the cost of the repairs to £4,050 17s. 7d., including the value of cable from our stock. This amount has been paid by transferring £1,674 5s. 3d., the balance of the contingencies account, and by taking £2,376 12s. 4d. from the reserve fund, and it is intended to repay this amount to the revenue fund out of future profits. Some exceptional expenditure was incurred during the past half-year, the principal items being on account of the removal of their station at Marseilles to the new post office in that town, and special repairs effected on the underground cables at Falmouth and at Bilbao. Of the balance of profit and loss, £2,500 have been put to the reserve fund (which now amounts to £26,445 19s. 4d.), leaving £2,528 12s. 11d. Out of this amount the directors recommend the payment of the dividend at the rate of 10 per cent. per annum on the preference shares, and a dividend at the rate of 4 per cent. per annum (free of income tax) on the ordinary shares, making, with the previous distribution, 4½ per cent. for the year 1891. A balance of £31 13s. 4d. is carried forward. The dividend warrants will be issued on April 1st, 1892. Sir James Anderson and Mr. Denison Pender are the directors retiring by rotation, and offer themselves for re-election. The auditor, Mr. Herbert R. Duke, retires, and offers himself for re-election.

Brush Electrical Engineering Company, Limited.—A prospectus, dated 16th inst., states that the directors are issuing £125,000 4½ per cent. perpetual debenture stock at the price of 101 per cent. for the purposes of redeeming the existing £75,000 6 per cent. mortgage debentures of the company, and of providing additional capital for its increasing business. The annual interest on this debenture stock now offered for subscription will amount to only £5,625. It will bear interest in perpetuity at the rate of £4½ per cent., and is secured by deposit of debentures, and a trust deed, dated March 14th, 1892, and made between the Brush Electrical Engineering Company, Limited, and the Electric and General Investment Company, Limited, as trustees for the debenture shareholders. The new stock will operate as a first charge by way of floating security upon the whole undertaking and property of the company, present and future, with the exception of the Vienna undertaking, pending a contemplated re-arrangement of the company's interest therein. A stock exchange quotation for the debenture stock will be applied for. The list of subscriptions opened yesterday, 17th inst., and will close on or before Monday next, 21st inst., at 4 p.m. for London, and at 11 a.m. on the following day for the country.

Eastern Telegraph Company, Limited.—The Eastern Telegraph Company, Limited, announce the payment on April 14th next of interest of 3s. per share, less income tax, being at the rate of 6 per cent. per annum on the preference shares of the company for the quarter ending March 31st; and the usual interim dividend of 2s. 6d. per share on the ordinary shares, free of income tax, in respect of profits for the quarter ended December 31st last. The register of transfers will be closed from April 7th to 14th both days inclusive.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (March 10th.)	Closing Quotation. (March 17th.)	Business done during week ending (March 17th, 1892.) Highest.	Lowest.
250,000/	African Direct Telegraph, Ltd., 4 p. c., Deb. Regd. and to Bearer	100	99 —102	100 — 103	101⅜	...
1,300,980/	Anglo-American Telegraph, Limited	Stock	49 — 50	49½ — 50½	50	...
2,849,510/	Do. do. 6 p. c. Preferred	Stock	88 — 89	88¼ — 89½	89¼	88½
2,849,510/	Do. do. Deferred	Stock	11½ — 12¼	12 — 12½	12¼	12⅛
130,000	Brazilian Submarine Telegraph, Limited	10	10¾ — 11¼	10¾ — 11¼	11 3/16	10⅞
53,200/	Do. do. 5 p. c. Bonds	100	100 —103	100 —103	...	...
75,000/	Do. do. 5 p. c., 2nd Series, repayable in June, 1906 ...	100	104 —108	104 —108	...	...
77,978	Brush Electrical Engineering Ordinary, Nos. 1 to 63,416	3	3⅛ — 3⅜	3⅛ — 3⅜	3¼	3 1/16
69,996	Do. do. Non cum. 6 p. c. Preference, Nos. 1 to 63,416	2	2 — 2¼	2⅛ — 2⅜	2 5/16	2 1/16
40,000	Chili Telephone, Limited, Nos. 1 to 40,000	5	3 — 4	3 — 4	...	...
50,000	City and South London Railway, Nos. 1 to 50,000	10	2½ — 3½	2½ — 3½	...	...
30,152	City of London Elec. Lighting Co., Ltd., Ord. 40,001-70,152, £4 paid	10	8 — 8½	7⅞ — 8¼	8¼	8 3/16
£7,716,000	Commercial Cable, Capital Stock	$100	155 —160	151 —156 xd	155⅝	155⅜
224,850	Consolidated Telephone Construction and Maintenance, Limited ..	14/-	⅜ — ½	⅜ — ½	...	...
20,000	Crompton & Co., Ltd, 7 p. c. Cum. Pref. Shares, Nos. 1 to 20,000	5	5½ — 6	5½ — 6	5 13/16	...
16,000	Cuba Telegraph, Limited	10	10 — 11	10 — 11	10 5/16	...
6,000	Do. do. 10 p. c. Preference	10	16½ — 17½	16½ — 17½	...	...
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	3¼ — 3⅜	3¼ — 3⅜	...	...
6,000	Do. do. 10 p. c. Preference	5	8½ — 9½	8½ — 9½	...	...
60,710	Direct United States Cable, Limited, 1877	20	11 — 11¼	11⅛ — 11⅜	11⅜	11
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14⅝ — 14¾	14⅝ — 14¾	14¾	14⅝
70,000	Do. 6 p. c. Preference	10	15 — 15½	15 — 15½	15½	15¼
200,000/	Do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	106 —109	106 —109	...	...
1,200,000/	Do. 4 p. c. Mortgage Debenture Stock	Stock	108 —111	108 — 111	110	108½
250,000	Eastern Extension, Australasia and China Telegraph, Limited ...	10	14⅞ — 15⅛	14⅞ — 15⅛	15⅛	14¾
78,300/	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	102 —105	102 —105	...	...
276,200/	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400 ...	100	102 —105	102 —105	...	...
320,000/	Do. 4 p. c. Debenture Stock	Stock	106 —109	106 —109	108	...
135,000/	Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	101 —104	101 —104	103¾	102
180,400/	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	101 —104	101 —104	103¾	...
201,600/	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	99 —102	99 —102	...	...
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	5⅝ — 6¼	5⅝ — 6¼	6 7/16	6 1/16
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	... ..	... ...	...	...
66,750	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	2¼ — 2½	1⅞ — 2⅛	2 3/16	1 13/16
70,000	Elmore's Patent Copper Depositing, Limited., Nos. 1 to 70,000 ...	2	3 — 3¼	2⅞ — 3⅛	3⅛	3 1/16
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	1⅝ — 1¾	1⅝ — 1¾	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 10s. only paid)	5	2 — 3	2 — 3	...	...
180,227	Globe Telegraph and Trust, Limited	10	9⅞ — 10⅛	9⅞ — 10⅛	10⅛	9 13/16
180,042	Do. do. 6 p. c. Preference	10	14⅞ — 15⅛	14⅞ — 15⅛	15⅛	14 13/16
150,000	Great Northern Tel. Company of Copenhagen	10	18¾ — 19¼	18¾ — 19¼	19¼	18¾
220,000/	Do. do. 5 p. c. Debs. (issue of 1883) ...	100	105 —108	105 —108	...	...
12,134/	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000 ...	10	7¾ — 8¼	7¾ — 8¼	...	...
9,600/	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	9½ — 10½	9½ — 10½	...	...
41,600	India-Rubber, Gutta Percha and Telegraph Works, Limited ..	10	19⅓ — 20⅓	19⅓ — 20⅓	19⅞	19⅝
200,000/	Do. do. 4½ p. c., Deb., 1896	100	103 —106	103 —106	...	...
17,000	Indo-European Telegraph, Limited	25	41 — 43	41 — 43	42¾	41⅞
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000	10	3½ — 4½	4 — 5	5	...
11,334	Do. do. Preference Nos. 5,667 to 17,000 ...	10	8 — 9	8 — 9	...	...
30,000	†Liverpool Electric Supply, £3 paid	5	2⅝ — 2⅞	2⅝ — 3	2⅞	2⅝
10,000	Do. do. fully paid	5	4½ — 5	4⅞ — 5	4⅞	...
38,348	London Platino-Brazilian Telegraph, Limited	10	6 — 7	6 — 7	...	...
100,000/	Do. do. do. 6 p. c. Debentures	100	105 —108	105 —108	...	...
49,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£9 paid)	10	8½ — 9	8½ — 9	8⅝	...
447,234	National Telephone, Limited, Nos. 1. to 438,984	5	4⅛ — 4⅜	4¼ — 4½	4⅜	4¼
15,000	Do. 6 p. c. Cum., 1st Preference	10	12½ — 13½	12½ — 13½	13	...
15,000	Do. 6. p. c. Cum. 2nd Preference	10	11½ — 12½	11½ — 12½	12½	12 1/2
420,000/	Do. 4½ p.c. Deb. Stock Prov. Certs. fully paid ...	...	104 —107	105 —107	106⅜	105½
250,000/	Do. (issued at 5 p.m., all paid)	...	79 — 81	79 — 81	...	...
6,318	Notting Hill Electric Lighting Company, Limited, £8 paid ...	10	4½ — 5½	4½ — 5½	...	...
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	⅛ — 3/16	⅛ — 3/16	...	...
9,000	Reuter's Limited	8	7½ — 8	7½ — 8	...	...
1*,680	St. James's & Pall Mall Electric Light Co., Ltd., Ord., 101—18,780	5	8¼ — 8⅜	8¼ — 8⅜	8½	8 5/16
20 000	Do. do. 7 per cent. pref., Nos. 20,081 to 40,080	5	7½ — 7⅝	7¼ — 7⅜	7⅜	7⅓
3,381	Submarine Cables Trust	Cert.	117 —122	115 —120	120	...
78,949	Swan United Electric Light, Limited ... ... (£3½ only paid)	5	4 — 4½	4 — 4¼	4⅜	4¼
37,350	Telegraph Construction and Maintenance, Limited	12	44 — 46	43 — 45 xd	44¼	43½
150,000/	Do. do. do. 5 p. c. Bonds, red. 1894	100	101 —104	101 —104	...	...
58,000	United River Plate Telephone, Limited	5	1½ — 2½	2 — 3	...	...
146,370/	Do. do. 5 p. c. Debenture Stock ...	Stock	80 — 90	85 — 95	...	...
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	7 — 8	7 — 8	...	...
271,400/	Do. do. do. 5 p. c. Debentures	100	99 —102	99 —102	100	...
30,000	West Coast of America Telegraph, Limited	10	4 — 5	4 — 5	...	...
150,000/	Do. do. do. 8 p. c. Debs., repayable 1902 ...	100	102 — 106	102 —106	...	...
67,007	Western and Brazilian Telegraph, Limited	15	10 — 10½	10¼ — 10⅜	10 7/16	10¼
30,364	Do. do. do. 5 p. c. Cum. Preferred	7½	6 — 6½	6¼ — 6⅜	6 7/16	6 5/16
30,364	Do. do. do. 5 p. c. Deferred	7½	3⅜ — 4¼	4 — 4½	4¼	...
189,700/	Do. do. do. 6 p. c. Debentures "A," 1910 ...	100	102 —105	102 —105	...	...
237,200/	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	102 —105	102 —105	...	...
88,321	West India and Panama Telegraph, Limited	10	1⅝ — 1⅞	1⅝ — 1⅞	...	...
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	9¼ — 10¼	9⅜ — 10¼	10⅛	10
4,669	Do. do. do. 6 p. c. 2nd Preference ...	10	8½ — 9½	8½ — 9¼	...	...
80,000/	Do. do. 5 per cent debentures (1917) No. 1 to 1,000	100	99 — 103	99 — 103	...	...
$1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	$1,000	118 —122	118 —122	...	...
173,100/	Do. do. 6 p. c. Sterling Bonds	100	97 —100	97 —100	...	...
59,900	*Westminster Electric Supply Corp., Ord., Nos. 101 to 42,953 ...	5	6¼ — 6⅜	6¼ — 6⅜	6⅝	6 7/16

* Subject to Founders' Shares. † Quotations on Liverpool Stock Exchange.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED:—Blackpool Electric Tramway Company, Limited, £10 (£6½ paid) 7¼—7⅜.—Electric and General Investment, shares of £5 (£1 paid), 2—2½.—Founders' shares, 150—200.—Elmore Foreign and Colonial Copper, Founders' shares, 6⅜—7½.—European Sims-Edison Torpedo Company, shares £20 (fully paid), 20—20½.—Founders' shares, 10—20.—Halifax and Bermuda Cable, 4½ per cent. bonds 80—90.—House to House Company (£5 paid) 4½—5.—7 per cent. Preference Shares of £5 (fully paid) 5¼—5⅝.—Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid), 5¾—6, 1st Preference Cumulative 6 per cent., £5 (fullypaid), 5¾—6.—Liverpool Electric Supply Shares of £5 (fully paid), 4⅜—5.—Do. shares of £5 (£3 paid), 2⅜—2⅝.—London Electric Supply Corporation, Ordinary (£5 paid), ⅛—1⅛.—Do. 6 per cent. Preference, 1¼—1⅝.—Manchester, Edison and Swan Company, £9 (£1 paid), ⅛—⅜.—Metropolitan Electric Supply Company, Founders' Shares, 450—500.—Queen Anne's Mansions Lighting and Heating, Deferred shares of £10 (fully paid), 10—¼.—Do. 4½ per cent. preference shares of £10 (fully paid), 10—¼.—Do. Debentures, 103—½.—Woodhouse & Rawson Ordinary of £5 (£2 10s. paid), ⅛—1.—£5 Preference (fully paid), 2¼—2⅜.—Ward's Electric Car (£10 paid), 1⅜—1⅝.

BANK RATE OF DISCOUNT.—3 per cent. (January 21st, 1892).

AUSTRALIAN ELECTRICAL NOTES.

[FROM OUR OWN CORRESPONDENT.]

LAUNCESTON is beginning to wake up again and consider the question of electrically lighting the city. About two years ago an attempt was made to bring in a private electric lighting Bill but it was thrown out on the understanding that the Municipal Council was going to undertake both public and private lighting. Mr. K. L. Murray, M.I.E.E., electrical engineer to the Victorian Government Railways, has recently submitted a report to the council which has been practically adopted. Mr. Murray proposes to obtain his power from the South Esk River, in which there is a considerable fall of about 140 feet in all, extending over a number of cataracts quite close to the town. A former plan arranged for the bringing of some 800 horse-power from a point known as Duck Reach to the first basin by means of a 40-inch pipe, and from there transmit electrically into the city. Mr. Murray found, however, that only 400 horse-power would be required for the present and that by using a 42-inch pipe a sufficient fall could be obtained to give this power at a point not more than a quarter of the distance above the First Basin. The present proposal is to have the generation station at First Basin and from there run a 42-inch pipe to a point 55 chains up the river where the intake would be situated. The total head obtainable by this method is 110 feet, but as it is proposed to place the generating machinery at a height of 35 feet, this allows 75 feet only, which it is proposed to increase to 90 feet by means of suction pipes. Reckoning on turbines giving 70 per cent. efficiency, 470 horse-power will be available for the dynamos, at an expenditure of 5,900 cubic feet of water per minute.

The streets are to be lit by means of 122 arc lamps of 1,100 candle-power for the main business part, and 200 50-candle-power incandescent lamps for the residential outlying parts. The circuits are to be arranged as in the Sydney scheme, so that, should a breakdown occur in any one circuit, the lamps extinguished will not be all in the same block, but distributed over several blocks and having lamps fed from other circuits between them. By this means also it will be possible, if necessary, to shut down half the lights after midnight, there still remaining as much light as circumstances require. The arc lamps are to be on wooden poles 30 feet high fixed in the middle of the streets, and the incandescent lamps on 20 feet wooden poles, all wiring to be overhead.

To provide for this street lighting there will be five arc light dynamos and two incandescent light dynamos, one of each being spare machines, and each machine to be coupled direct to a separate turbine; the turbines for the arc dynamos to be of 20 horse-power each, and of 90 horse-power for the incandescent dynamos. In addition the report provides for four more incandescent dynamos for lighting Municipal and Government buildings and for private lighting sufficient for actually maintaining 2,600 16-candle-power lamps and allowing for wiring 3,500. The private and street incandescent lighting will be supplied by means of alternating currents at 2,000 volts pressure, reduced to 100 volts at the transformers; for this purpose Mr. Murray divides the residential and outlying parts of the city into four districts, in each of which will be fixed transformers connected direct with the dynamo at the generating station and forming small sub-stations, both private and street lighting being supplied from the same transformers. Transformers are reckoned for a total capacity of 290 kilowatts.

The details of estimated cost are as follows:—Dam and race, £700; piping at 42s. per foot, with £1 per ton added for carriage, £7,950; labour, £1,800; tail-race, £300, or a total of £10,750 for the water scheme. Buildings and foundations, with a floor space of about 50 feet by 90 feet, are reckoned to cost £2,000. The costs of the various items of machinery are calculated as follows:—Turbines, six at £120 and five at £100 = £1,220; dynamos, six at £550 and five at £250 = £4,550; regulating apparatus, switchboard, measuring instruments, &c., £1,200; leads and cables, *i.e.*, 20 miles to arc lamps, 18 miles to transformers, 26 miles from transformers to street lamps, £9,000; 50 miles steel suspension wire, £100; transformers, £2,000; arc lamps and lanterns, £2,625; incandescent lamps and holders, £150; shades and protectors, £250; switches and cut-outs, £50; poles, £1,500; oil insulators for high tension leads, £500; meters, £500; fixing poles, leads, &c., £1,000; fixing machinery, suction pipes, &c., £1,000; contingencies, engineer's commission, supervision, &c., £3,000, or a total cost of £41,395.

The annual cost of maintenance is reckoned at £4,980, and is made up of the following items:—Interest on £42,000 at 4½ per cent., £1,890; depreciation of plant, £1,260; one engineer at £300, two assistants at £150 each; two lamp trimmers at £130 each; carbons, £720; oil waste, &c., £100; and incandescent lamp renewals, £150. The revenue is estimated at £7,732 10s. per annum, reckoning £1,517 10s. for street lighting, which is the price paid at present for gas; £615 for the lighting of 1,300 16-candle-power lamps in Municipal and Government buildings, reckoning on a consumption of 21,140 B.T.U. at 7d. per unit; £3,930 for 134,860 units for private lighting; £1,500 for 150 horse-power motive power at one penny per H.P. hour privately taken up, and 170 for motive-power for Municipal stone-crusher.

The report also includes a scheme for electric trams, the details of cost, &c., being worked out for three routes, having a total of six miles in all—three miles of double track and three miles of single track. The cost is estimated on a 4 feet 8½-inch gauge as follows:—Three miles of double track, £13,800; three miles of single track, £6,900; 13 cars, including motors and all equipment, £9,100; electric line, return, &c., £5,400. Total, £35,200. The cost of maintenance is taken at 7d. per car mile inclusive of everything; four cars would be used on each route, running at an average speed of nine miles an hour, allowing for a service of one car every eight minutes, assuming each car to run 95 miles per day; with this cost of maintenance, 2,660 fares at 3d. each would have to be taken to cover the expenses.

In the event of an increase of power being wanted, Mr. Murray provides for this by fixing a 40-inch pipe on top of the 42-inch pipe, the masonry piers, &c., being made of sufficient strength in the first instance to allow of this extension being made; this will give 390 horse-power additional at a cost of £8,263. The report shows evidence of having been very carefully considered and worked out, more especially with regard to the method of securing the necessary water power. Attached to it are drawings showing proposed method of fixing the arc and incandescent lamps on the poles, insulator for overhead wire for tram, a tramcar with trolly, and a figure showing a street with poles carrying lamps and arms for tram wires.

It seems a pity to see so much power going to waste so near a city, when one considers how successfully it can be utilised by means of electricity; the only use made of the South Esk cataracts is at a flour mill situated just at the junction of the Tamar and South Esk. The power is brought by means of an open wood flume, about 4 feet by 2 feet, which is some 50 years old and very leaky. At the mill a fall of about 27 feet is obtained, and by means of a Chiara movable channel turbine, from 10 to 30 horse-power is utilised for the purposes of the mill.

EXCAVATING TUNNELS AND ADITS BY THE ELECTRICAL TRANSFER OF POWER.

[FROM OUR OWN CORRESPONDENT.]

(*Concluded from page* 318.)

BY this arrangement, if apparatus of the larger sizes are used, the front wall is worked out in as many stages as there are stars present.

The frame above-mentioned is built upon two pairs of wheels, the foremost pair of which is fixed permanently, whilst the hind pair can be displaced either laterally or vertically, so that any necessary changes of direction in the adit can be effected. The adjustment of the machine to changes of direction is done by hand, by means of wheels, spindles and spirals.

The advance of the boring machine against the front wall

of the tunnel takes place whilst it is in action, and is done in small machines by hand, but in larger machines mechanically, but it is always capable of regulation. To this end there is fixed on the shaft, or otherwise upon its sheathings, an eccentric, which sets in motion a double-action displacement wheel. The axle of the latter bears a spiral, which catches in a spiral wheel, capable of revolving loosely on the axle of the front wheels. For boring work it is connected with the running wheel, so that the rotation of the spiral is communicated to the running axle. When out of working hours the machine has to be moved forwards or backwards, it is disconnected, and the running axle can then be turned independently.

The transferring belt which conveys the earth, &c., away over the machine, runs over two fixed rollers, and over a tightening disc. One disc is driven from the main shaft of the motor by means of toothed wheels and belts.

The arms of the largest or hindermost boring "star," carry each at their ends, on the posterior side a flat scooping vessel, a shovel which takes the stones which have fallen to the ground, raises them aloft and empties them into a hopper, which is placed above the transfer band laterally, and effects the distribution of the excavated matter.

The transfer band receives so rapid a movement, that the excavated matter is forcibly thrown behind the machine, and is conveyed through sheet-iron shoots directly into the dogs.

In order to prevent the borings and dust from falling into the movable parts of the machine, they are enclosed in a sheet iron casing, which protects especially the toothed wheels and journals. The journals most exposed to dust are constructed so as to be closed. These journals form chambers, which are totally enclosed, and are in part filled with lubricating oil.

As above mentioned, the adits or tunnels are fitted with a provisional structure, which, in loose formations, shields the sheet-metal casing against the collapse of the roof or sides, and in all cases renders possible the continuous extension of the rails which lie on the floor of the excavation, as also the construction of the "flying line." The provisional structure is thus arranged:

Three-fold circular rings of the diameter of the tunnel are erected and built in at distances of 1 metre each directly behind the machine, but in loose earth close behind the boring "stars," and screwed tightly together. These rings adapt themselves to the cylindrical surface of the adit, and are able not only to resist a very considerable pressure, but also to support the "flying line." In loose earth the sheet iron casing is first inserted, supported, and then secured by the rings.

The part of the rings resting upon the floor of the adit is formed with plates of L iron, so that the heavy machines may not press down the structure into the rock.

The rails are introduced in pieces of 1 metre in length, and screwed down to these bottom plates.

The U-shaped rails of the "flying line" are laid and screwed upon arches, which are also secured to the rings. The prolongation of the "flying line" is undertaken immediately behind the machine, keeping step with its advances.

The "flying line" must return into itself so that the dogs can effect their circuit. This is effected by means of rails bent in a semicircle. The current is brought up by means of insulated flexible cables, which are suspended to the arches of the flying line by means of porcelain rollers fixed on the cables. The cables are applied in pieces of 25 metres, and fixed in coils upon the machine from which they are unrolled. When the adit is fitted up with facilities for electric working, the conveyance of the current may be connected with the definitive conduction of the line.

For lighting the adit, ventilation, drainage, &c., arrangements are made according to local conditions. The necessary installations for these purposes can be more easily carried out during the progress of the boring than after the motive power has been already established. The ultimate lining of the adit or the tunnel may either be effected by a simple coating of cement, as in the case of absolutely solid rock, or a lining is introduced capable of resisting pressure, and varying in its nature according to local circumstances. For adits in mines, cross cuttings, &c., an iron coating is recommended.

LEGAL.

Lane-Fox v. Kensington and Knightsbridge Electric Lighting Company.

(*Continued from page* 339.)

Saturday, March 5th, 1892.

Sir Frederick Bramwell was further cross-examined by the Attorney-General as follows: Supposing a battery of increased number of plates will discharge a 50 ampère current at between 104 and 90 watts for 20 hours?—At 20 hours that would be 1,000 ampère hours.

If you put another battery side by side, and coupled it up parallel, you would double that number of ampère hours?—Yes, or as I said probably a little more.

You are aware that if you suddenly switch on or off 2 volts, you can see a little increase or decrease?—Yes.

The gradual fall of 2 volts from 104 to 102 is, unless you are watching the light, imperceptible?—Yes.

Assuming the generator and the secondary batteries kept constant within those limits, will they not maintain a constant pressure on the lamps whether 10, 20, 30, or 50 lamps are turned on or off?—Yes, they will not flicker.

Is not that to a great extent due to the regulating action of the secondary batteries?—I do not think so in a steam-driven plant.

Is not the absence of flicker largely due to the secondary batteries?—Again I say I believe not.

Do you say the batteries have no influence in that direction?—I do not say that. When two things are coupled together, it is impossible to say that one is without influence. I say that without the battery the thing would be uniform for commercial purposes.

Mr. Justice Smith: What are you driving at?

The Attorney-General: That the user of the secondary batteries most distinctly regulates these lamps, and keeps the lamps constant whenever they use them.

Mr. Justice A. L. Smith: I do not think there is much doubt about that.

Witness: In my opinion you cannot have secondary batteries suddenly coupled up for the purposes of storage without at the same time there being as an incident of that use an amount of regulation.

If secondary batteries are coupled up in the position Mr. Lane-Fox has described, would not the presence of these batteries prevent the fall of the voltage to a large extent in the lamp circuit?—I don't think so; the batteries would discharge a larger number of ampères.

I put it to you practically; at the lights will not the presence of these secondary batteries prevent a considerable portion of that falling of voltage at the lamps?—I think not a considerable, but some portion.

Assuming the generator to be running, and the batteries to be charging and discharging as the main circuit draws or allows it to go in, is it not the fact that you do not require to switch in more cells unless the potential at the battery falls below that which you wish to deliver to the lamps?—Yes.

Is not the result of running direct from the dynamo with a gas engine that you have a perpetual tremor?—Commonly.

Is not the result of the secondary batteries, as used by Mr. Lane-Fox, to diminish that tremor?—Yes.

Is not that flickering due to the irregularities of voltage, owing to the irregular action of the gas engine?—Yes. When the whole thing is in good order you cannot with the naked eye detect the tremor caused by the impulses of the gas engine. Gas engines were used up to 400, 500, or even 1,000 lights.

What do you understand by "the earth" in the specification?—I suggest that it does include the soil.

Are you aware that earth returns are contemplated by the Board of Trade?—I think they are in the sense that they are prohibited.

There being some reason or sense in the Board of Trade, they were prohibited because they were thought possible?—Yes.

You know that the Board of Trade have prohibited earth returns?—No; they have prohibited uninsulated conductors; whether they also prohibited earth, I do not know.

You do not suggest that the Board of Trade prohibited earth returns if they were impossible?—I understand it is a prohibition against uninsulated metallic returns.

From the point of view of Mr. Lane-Fox's system, would it make any difference whether that strip of copper was insulated or not?—I think not.

From the point of view of the return of the current to complete the circuit, does it make the slightest difference whether the return conductor was insulated or not?—No.

Was not the great problem in 1878 distribution of the electric light?—Yes.

Was a Government enquiry held in 1879 with reference to the practicability of electric lighting?—It was. Most of the leading electricians gave evidence, and I believe the general opinion was that there was at that time no well-known system of dividing the electric light.

Had anybody to your knowledge, prior to 1879, published any practical system of distribution by multiple parallel luminous incandescent bridge?

Witness, in the course of a lengthy and much qualified answer, said that he did not recollect any such publication with reference to an incandescent bridge pure and simple, but he thought he did with reference to a semi-incandescent bridge. He believed the patent he referred to was taken out in America, and published in this country. He could not give an instance of arc lamps being worked in parallel

in 1878. For distribution at the lamps, it did not matter whether an insulated or uninsulated, or an earth conductor were used, so long as the current got back to the lamps. The evil results of connecting by means of the gas and water pipes would be cured by insulating the conductor.

Prior to 1878, was there any known method of distributing 50 ampères by incandescent bridges?—I do not remember.

Do you say that 50 ampères would not go back by earth?—I do not think it is impossible with an adequate size of earth plate.

Do you suggest that 50 ampères would not go back electrically by the gas and water pipes perfectly?—If they were continued throughout as a metallic circuit, certainly; if used as earth plates only, no.

Is not the real question of the unsuitability of the soil return the magnitude of the current you are dealing with?—Certainly.

Are you aware of the ampèrage of the current in the Leeds tramways?—No.

Do you know that it was so strong that telephone wire and telegraphic wire for a considerable distance had been disturbed?—I know it second hand.

Is the railway from the monument to Southwark worked with an earth return?—No, it is worked by a separate metallic conductor enclosed in an iron tube except at the station.

That would be uninsulated?—Yes.

Do you agree that Clarke proposes to have a momentary discharge for ringing bells, and a momentary discharge for lighting the tinder boxes or incandescing the platinum wire?—He proposes to have momentary discharges, but to have very many repetitions.

He did not contemplate the secondary batteries in constant connection so that it could be charged or discharged as the pressure in the conductor required?—He contemplated it in constant connection so that it could be charged; he did not contemplate it in constant connection so that it could be discharged.

With or without the aid of secondary batteries, can you produce a single reference to Clarke or a development of Clarke, prior to 1878, or subsequently, with the object of breaking up the current at a constant potential?—I do not know.

Had you ever considered Clarke's specification, with reference to this problem, until you were asked to advise your own company in this defence?—I don't think before.

Mr. JUSTICE A. L. SMITH: Haven't we had enough of Clarke.

The ATTORNEY-GENERAL: Who will give me the number of secondary batteries you have at Kensington and Queen's Gate—the ampère hours in the cells, &c.?—Mr. Crompton.

Mr. JUSTICE A. L. SMITH asked the witness if the great difference between the plaintiff's and the defendants' system of distribution was not that the one worked automatically and the other worked by hand.

WITNESS: I think so, my lord.

Re-examined by Mr. FINLAY, Q.C.: There was nothing in the plaintiff's specification to indicate that several generating machines were to be scattered about the system. In Clarke's patent it was pointed out that there was sufficient electromotive force to ring the bells for an hour or more.

How do you regulate?—By the variation in the number of cells in use, or by the variation of the dynamos.

Is the regulation automatic?—Certainly not; except in so far as it is an incident of the action at any particular moment; but so far as the practical regulation is concerned, it is not automatic, and I further add that with a steam driven plant we could work perfectly if we threw the batteries out altogether.

What do you understand Lane-Fox pure and simple to be?—Automatic.

Dr. JOHN HOPKINSON, F.R.S., &c., examined by Mr. WALLACE, said he had given great attention to electricity for the last 14 years. In purely scientific work he had devoted all his time to electric subjects. He had read the plaintiff's specifications and examined the defendants' works.

What do you find in the plaintiff's specification after what is disclaimed?—I find a combination of a system of mains, described in detail, of a generating instrument, and of secondary batteries connected with those mains.

Do the defendants employ a lamp of the description described in the plaintiff's patent?—No, they use a carbon lamp in vacuum.

At the date of this patent were platinum and iridium lamps well known?—Yes, in the laboratory; they never were known commercially.

Mr. JUSTICE A. L. SMITH: The lamp has been disclaimed.

The ATTORNEY-GENERAL: I rely distinctly on the system of distribution, which is all that is claimed. I say that is new.

Mr. JUSTICE A. L. SMITH: And you say the system of distribution involves regulation, and that you claim?

The ATTORNEY-GENERAL: Yes. I only claim the lamp in combination with the system of distribution.

Mr. JUSTICE A. L. SMITH: Let's leave the lamps alone. They are not the question.

Mr. WALLACE: The plaintiff connects one of his poles to the earth?—Yes.

What does he mean by "the earth" or "earth?"—I have never heard until in connection with this patent "the earth" used, except in connection with the soil of the earth, or as to conductors ready existing in connection with the soil of the earth.

What difference do you find between the "earth" as a dictionary word, and that word as used by electricians?—I find none, except I think it is possible you may find cases in which "the earth" was used as applied to objects which you find ready to hand, as, for example, gas and water pipes.

Mr. JUSTICE A. L. SMITH: If you had an insulated wire, what would you call it?

WITNESS: An insulated wire. This is what I take to be meant by "earth" or "the earth" in its technical signification—the soil of the earth or any electrical connection to earth which an electrician finds ready placed to his hand, and uses as his second conductor, and so saves the expense of using a special conductor *ad hoc*.

Mr. WALLACE: On your definition, what do you say with regard to gas and water pipes?—I should say that gas and water pipes would be "earth" or "the earth." In the plaintiff's specification, *e* was equivalent to earth plate. Witness having given several references to scientific works, with a view of showing that earth in its technical sense was used in the way he had given in his definition,

Mr. JUSTICE A. L. SMITH: Do you say that this return of Lane-Fox's could be worked by earth?

WITNESS: Only on a very small scale indeed. It is difficult to give figures—it depends on the character of the earth.

Mr. JUSTICE A. L. SMITH: Take an average earth.

WITNESS: Taking an average earth, I should not be afraid of working 10 ampères, but it would be very uneasy working at 100 ampères. I do not say it could not be done. I think I might say positively you could not do it up to 1,000.

Mr. JUSTICE A. L. SMITH: What do you say it could be done practically at?—Practically, I do not think you could go beyond a hundred. If you have 1,000 ampères that will oxidise about 2 lbs. of iron per hour. That would be serious with water pipes, as the oxidisation would be localised. Apart from that, you would have insuperable difficulties by reason of the resistance that would be introduced.

Mr. WALLACE: On such a system as contemplated by this patent would earth returns be successful?—I think not.

Mr. JUSTICE A. L. SMITH asked witness if he knew of any installation in which a soil return had been used.

WITNESS said that he believed Sir William Siemens put up a small installation of about 10 ampères at Holyhead in which the soil was used as a return: in the word soil he included the sea.

In answer to Mr. WALLACE, WITNESS said that Kosloff's and other specifications described a system of incandescent lighting in parallel distribution.

Mr. JUSTICE A. L. SMITH: Do you put these in as anticipations?

Mr. WALLACE: No. In order to be anticipations they must be claims or patents which show secondary batteries with such a system of distribution as described by the plaintiff.

Mr. JUSTICE A. L. SMITH: Quite so; that is what I was leading up to. What is the good of them?

Mr. WALLACE: One of our contentions is, that secondary batteries being well known, putting the two things together you could not get good subject matter for a patent.

Examination continued: A condenser in 1878 would have been known to be something quite distinct from a Planté battery. There was no special merit in 100 volts. He should imagine 100 was used because it was a round number, but he could not tell what Mr. Lane-Fox had in his mind. Under Staite's specification the voltage of the cells would vary according to what patentee's cells were used. In 1845, Daniell's cells were most commonly in use, and if Daniell's cells were used the voltage would be, approximately, 100. All secondary batteries practically used were lead and sulphuric acid batteries.

What do you understand by a reservoir of electricity?—Something in which a reserve is to be stored. As I understand it, what the patentee intends is to have a dynamo machine giving an approximately constant current. When the number of lamps is small, and the demand consequently small, he proposes to allow the excess of current to flow into the battery and be there stored. When the demand is great, he proposes to allow the current to flow out of the battery and to aid the dynamo.

Mr. JUSTICE A. L. SMITH: Is that the use to which the defendants put their batteries?—Incidentally, but their main object is other.

Mr. JUSTICE A. L. SMITH: What is it?

WITNESS: The defendants' main object in using secondary batteries is—they are bound to supply a current at all hours of the day, and during many hours the demand is very small, and it is economical to allow the machinery to stand idle during those hours, because the services of a large number of workmen may be thus dispensed with; they therefore provide batteries which are charged when the machinery is running, and the demand consequently somewhat considerable, and are discharged when the demand is small.

Mr. JUSTICE A. L. SMITH: What is the great difference between the two?

WITNESS: In Mr. Lane-Fox's he charges the batteries when the demand is small, and discharges when the demand is great; in the defendants' case they charge the batteries when the demand is comparatively great, and then disconnect their machinery and discharge their batteries from the mains when the demand is small.

At this juncture the further hearing of the case was adjourned until Monday, 7th inst.

MONDAY, MARCH 7TH, 1892.

The examination of Dr. Hopkinson was proceeded with.

WITNESS in answer to Mr. WALLACE said that he gathered from the plaintiff's specification that the plaintiff had a number of batteries, and that these batteries might vary one from the other. He said that the placing of the battery at various parts of the circuit had the same kind of effect as the use of feeders when no batteries were used. The batteries, when being charged, required a higher electromotive force than they were capable of giving when discharging. He had made a series of experiments on batteries at his own house. Twenty-three cells were in use, and those 23 cells were connected to his lamp circuits, and were also connected to his dynamo machine. The dynamo was giving 33 ampères, of which 18 ampères passed into the battery, and the other 15 passed into the lamp circuit. The dynamo was started at 5.55 in the evening, and continued running under steady conditions until 10 o'clock in the evening. During the time the pressure on the battery increased from a pressure recorded at 6 o'clock of 48·6 volts to 52·4. The machine was then

stopped, and the fall of pressure whilst the battery was giving 15 ampères was noted. In less than the minute the pressure had fallen to 48·6; in one minute to 47·8; omitting intermediate minutes, in 12 minutes it was 45·8. He did not venture to run the experiment further with the 23 cells, because it would have injured his lamps; in fact, no doubt it did injure his lamps.

Is there a sudden rise in the batteries when you commence to charge your batteries?—That is always the case.

Mr. JUSTICE A. L. SMITH: With 100 volts and 50 cells, up to what potential do you say you must go to fill up to the plateau?

WITNESS said there was no plateau, but, assuming there were, the plateau would be reached before the cells were filled; he should think the plateau would be got well on to at 110, but the cells would not be full. He could tell when he got up to 52 volts by an instrument, or by the brightness of the lamps.

Mr. JUSTICE A. L. SMITH: Is the brightness of the lamps an ordinary way of finding out what voltage you have on?

WITNESS: It is frequently done for want of a better.

Mr. JUSTICE A. L. SMITH: A man who knew what he was about would be able to tell practically what the voltage was?

WITNESS: Very fairly. I think you could tell with certainty within 2 per cent.

Mr. WALLACE: What do you understand by the words, "they shall become charged"?—I gather they shall take their charge and discharge automatically.

What would be the effect of doing that?—In my opinion he would fail to get a sufficient charge into his batteries to preserve them. To do this he would have to charge his lamps up to 120, and that would rapidly destroy any lamps connected with the circuit.

Suppose the batteries were allowed to discharge automatically?—As the pressure on the battery fell the lamps would become dim.

Prof. FORBES gave it as his opinion that in these courts a gradual drop of 15 volts could go on without our noticing it?—I am certain I should notice a fraction of that, and anyone would.

It has been said that it is possible to charge batteries automatically with 101 volts. Do you agree with that?—No. What will happen will be this: If you put 101 volts on your battery you will get a small current for a short time, but that current will speedily diminish and become practically *nil*.

Is the direction that the cells should be large a sufficient direction to give to an electrical workman?—I should think not: it only points to the direction in which he should go.

What would you have to do to Clarke's patent to make it suitable for electric lighting?—You would have to add the switches requisite for varying the number of cells connected to the lamp circuits.

In answer to his LORDSHIP, WITNESS said that in 1878, if you had a cell full of electric energy, and you wanted to keep it in, you might use a switch; in any case you would break the circuit, the object of switches being to make and to break the connection of the circuits.

Mr. WALLACE: At the defendants, do the batteries keep the pressure constant?—Not to any appreciable extent.

What do they rely on for keeping the electromotive force constant?—They do keep it constant by the adjustment of the speed of the engine; by the use of the voltmeter they increase or diminish the speed of the engine.

What function do the feeders perform?—Feeders keep the pressure the same at distant parts of the mains as at the station itself.

Assuming the batteries were taken away, what would be the effect of the constancy of pressure in the defendants' system?—None. They are working in that way at Gatti's, in the Strand.

Cross-examined by the ATTORNEY-GENERAL: He had heard and read Sir Frederick Bramwell's examination and cross-examination, and knew of nothing that he wished to dissent from. At Kensington a man watches the voltmeter, and has to observe a very slight alteration. If the man did not happen to be quick in observing, the secondary batteries would mitigate the flicker, which would not be sensible to the eye. Fifty-volt lamps took double the quantity of current in ampères for the same light as 100-volt lamps. If he had 100-volt lamps, he would have had twice as many cells half the size. In 4½ hours the variation was 3·8 per cent.

Do you know of any description of any system prior to Lane-Fox's which would produce such a variation as that, or anything like it?—I do not think I remember any case of combination of incandescent lamps with a battery at all; nor, indeed, of dynamos which would be capable of giving a result like that.

Had secondary batteries ever been used at all before 1878 in connection with incandescent lighting?—Not that I know of.

When charged, a secondary battery performs the function of a primary battery—that of giving of electricity?—Yes.

By switching on more cells you restore to the partially discharged secondary battery its defective voltage?—Yes.

Just as it would in a primary?—Yes.

You were a witness at the Government Commission in 1879 to enquire into the practicability of lighting by electricity?—Yes.

Did not a question come up as to the practicability of sub-division of the electric light?—Yes.

Did you suggest that it was practical to sub-divide the electric light for incandescent purposes?—No, because there were no incandescent lamps. My own view was that the difficulty lay in the peculiarity of the arc; but I did not express it. I always held that there would be no difficulty with regard to the incandescent light.

After a long cross-examination on the effect produced by putting the model in certain position, WITNESS said gas began to come off at about 2·2 volts per cell, but the gas which came off them was extremely small. Charging was a relative term. The current could not be got in without applying an excess voltage. The real object of charging the cells at an excess voltage was to preserve them.

Was it common in laying cables to sheath them?—Yes, with iron, for the purpose of mechanical protection.

Can you find any book which puts your limitation—that earth means something which an engineer finds ready at hand, or puts there for another purpose?—No; most of the books define "earth" or "the earth" more restrictedly than I do.

You quite recently investigated Andrews's system of wiring for electric lighing?—Yes.

Mr. JUSTICE A. L. SMITH: What have we to do with Andrews?

The ATTORNEY-GENERAL said that if the language of the specification was soil, and soil would do for a small thing, then he said the ordinary electrical equivalents were not only allowed, but must be allowed to be included in dealing with a large installation.

To the WITNESS: Have you ever experimented upon the size of earth plates required for a given current?—No.

Do you know that earth returns, in the sense of uninsulated returns, are used for electric tramways?—Yes.

Does not the difficulty between the soil and an uninsulated conductor depend entirely upon making sufficient connection with the soil?—Yes.

And is not the question, practically speaking, a commercial question?—Yes.

WITNESS admitted that in a patent taken out in 1882, in describing the three-wire system, he said, referring to the intermediate conconductor, "It need not be insulated, and, indeed, it may be replaced by the iron or other metallic covering used to protect the copper wire. The intermediate conductor may, in some case, be replaced by the earth, and the negative pole of the dynamo machine, A, and the positive pole of the dynamo machine, B, be connected together and to the earth." He thought they were going to fight that patent some day, when he was happy to say the Attorney-General would be on the other side. (Laughter.) In 1878, when Mr. Lane-Fox, in writing to the *Times*, used the term "condensers," witness suggested that alternating currents were referred to. "Condenser," at that time, meant Leyden jar ordinarily, and secondary battery occasionally, by an improper extension of the term. Any ordinary electrician, reading that letter, would have brought to his mind Leyden jars, until there was something to contradict it.

Re-examined by Sir HORACE DAVEY, Q.C.: On the three-wire system, the current in the central wire was about one-tenth of the current in the outer wires. If the lamps on the outer wire were exactly balanced, there would be no current at all. The current it was proposed to carry to the earth would be, comparatively speaking, small. For the current to be kept constant in potential, it must be kept fairly constant in quantity. If lamps were put on the lighting circuit, that constancy would no longer exist, and a removal from one plateau to another would take place. By far the best way of meeting this variation was to make use of switches for varying the number of cells. Another way would be to provide more cells than were ever required, and to pass the current through a resistance, the amount of which could be varied at pleasure. There was no direction in Lane-Fox's patent which would lead the mind in that direction. At the time of Mr. Lane-Fox's patent there was no practicable incandescent lamp. The platinum iridium lamp was never a practicable lamp, and would never have become so. It was common experience that an iridium lamp was expensive to begin with, and not economical in working. Until Edison's lamp was invented in 1879 and came into use, there was no system of incandescent lighting, because there was no lamp. To that circumstance he attributed the fact that there had been no system of distribution of the electric light by incandescence before or after Lane-Fox's. Many proposals had been made prior to Lane-Fox's for distributing the light, but had not been carried out because of the want of a lamp. No one reading Lane-Fox's specification would have thought it necessary to have switches; they would have thought that the batteries themselves would be sufficient for regulation. If switches were introduced the system would cease to be automatic. The system of switching adopted by the defendants was the result of more thought and ingenuity than could be properly demanded from an intelligent electrical workman.

Mr. ROOKES EVELYN BELL CROMPTON was the next witness. Examined by Sir HORACE DAVEY, he said he was an electrical engineer, and managing director of the firm of Crompton & Co., Limited, whose business was that of general contractors, including the putting up of installations. He had been connected with that class of business since 1878. The profession of electrical engineering was new at that time, there being in England nobody in the business except Mr. Siemens, and Mr. Wilde, of Manchester. He designed the installation at Kensington, and carried it out as a contractor, commencing in 1886. In 1881 or 1882 he put up an installation at the Law Courts. He believed that was the first large system of incandescent lighting in England. He adopted a parallel system of distribution with several generating machines, and Faure, Sellon, and Volckmar cells. No switches were used other than those to put the whole of the batteries in and out of circuit. There were no means of putting in and out extra cells. The cells were the best that could be obtained, the company supplying them being as anxious to distinguish themselves as he was. They commenced without the batteries, driving direct from the dynamos, which were especially constructed to give constant pressure. The dynamos were called compound dynamos, and were almost the first of that class used in England. The lights in court before the accumulators was very constant. Later on he gave instructions for the accumulators to be switched on, and as soon as the accumulators were switched on, one out of the three lamps they were experimenting with burst. They then turned on the rest of the lamps, and finding them equally brilliant, they altered the batteries. Next they reduced the number of accumulators, with the result that for about 20 minutes the lamps were of the right brilliancy with the batteries on, but after that they again became too brilliant. He then stopped the engine, switched off the secondary batteries, and stopped the whole experiment. Next day he tried the experiment of switching on the secondary batteries alone without the assistance of the

dynamos, the secondary batteries being full, with the result that the lamps were not bright enough. They honestly did their best to make the secondary batteries work. Her Majesty's Office of Works ordered the accumulators to be removed, and their place taken by additional dynamos. So far as he knew there were no accumulators at work in the Courts now. Mr. Lane-Fox attributed the failure in the Courts to the cells being bad, and he accepted the explanation, not being wiser in those days.

Mr. JUSTICE A. L. SMITH: That is what he says, you know. (Laughter.)

WITNESS went on to say that he then devoted his attention to devising a scheme for making accumulators work. Difference of pressure being inherent to the use of accumulators, and finding that it could only be mitigated very slightly by increasing the active surface of the plates, he accepted the fact, and devised proper switches. Mr. Lane-Fox's installation at Vienna never worked. Two or three years after it was put up he was the contractor for the Imperial Continental Gas Association to put in a large installation which was now permanently there. That was the first installation in which multiple switches were used. He agreed in the main with the evidence given as to the defendants' system by Sir Frederick Bramwell and Dr. Hopkinson. From practical experience, he could say that the potential of the battery when discharging dropped so very quickly that they had to switch on more cells every few moments. He found it utterly impossible to charge a battery at all for the purpose of being worked continuously under a 15 per cent. rise from the point that it had dropped to when discharging. Witness was giving the result of experiments made by him when the Court rose for the day.

ELEVENTH DAY, TUESDAY, MARCH 8TH, 1892.

Mr. CROMPTON, examined by Sir HORACE DAVEY, Q.C., gave particulars of the tests applied to secondary batteries to obtain facts as to charging and discharging. He said that the first experiment was an attempt to charge with pressure never exceeding 1 per cent. above the normal. The cell came to grief, sulphating taking place at the end of 1 hour and 50 minutes. The second experiment was an attempt to charge with pressure never exceeding 2 per cent above the 100 normal. The object was to show clearly that this slow charge not only did not fill the cell, but also exercised a very hurtful effect on the cell. The cell so sulphated, that the whole of its charge passed away, consequent upon not charging the battery fully, In his opinion the consequence of not charging the cells at sufficiently high pressure, accounted for the whole of the failures of Mr. Lane-Fox to make them float—sometimes charging a little, and sometimes discharging a little. The third was a medium experiment. It was a charge extending for 18 hours, at a rate which he thought would fill the cell in 18 hours, but which did not do so, and it was continued for six hours. For practical working of the electric light, you wanted to charge and discharge your cell in 24 hours. He took 18 hours as the longest possible time Mr. Lane-Fox could claim for charging.

Mr. JUSTICE A. L. SMITH: This, I understand, is an ordinary trial at your works of Mr. Lane-Fox's system, pure and simple, without switches?—Yes.

WITNESS said that the fourth experiment was carried out by Mr. Miller, and would be spoken to by him. The fifth experiment was carried out to show the effect of passing at 5 minutes intervals from charging to discharging, and the result was to show that that was not practicable. Charging the batteries at less than their fair capacity did not keep the batteries in good order. That was the cause of all the failures at the Law Courts, of Mr. Lane-Fox's failures, and of those in most country houses. A competent electrician would not have introduced the defendants' system of switching without thought, labour, and ingenuity. It was only true to a very limited extent that if cells of a larger conducting surface were introduced the rise and fall of the current would be neutralised. That was the result of exhaustive experiments on his part. It was absolutely untrue that if the conducting surface were doubled the rise would be halved. No increase in the conducting surface would neutralise the rise absolutely. At Notting Hill Gate, the defendants had cells five times the ordinary size, and they did not neutralise the rise. There was nothing in the direction that the cells were to be of "large conducting surface," which conveyed anything definite to his mind. Planté's cells used in 1878 could not be said to have a large conducting surface. The batteries which the defendants used had a conducting surface thirty times as large. He was well acquainted with the installations in the United Kingdom and on the Continent which used accumulators. Good results were obtained at Berlin without accumulators, the light being all that could be desired. The secondary batteries as used by the defendants never alternately charged and discharged without the use of switches. After the lights were put out from 10 o'clock to 12 o'clock, the defendants left the batteries to act alone. If they heard that there would be an unusual demand for a particular purpose, the defendants kept their men at the works to do the switching; otherwise the supply might run short. Taking Lane-Fox's amended specification, he said that that did not supply him with sufficient directions to make a workable installation. By the direction that he was to make the pole of each electrode connect with the earth, he should understand that an earth plate was to be used, or that gas and water pipes were to be used. He found that earth plates were impracticable, and discontinued his experiments in connection with them. He tried water mains, but found that the resistance from the joints was so great that he had to make metallic connections. In the three-wire system, the effect of the mid wire going to earth accidentally was to produce corrosion. Electrolysis was confined to the wet places in pipes, and was proportionate to the strength of the current. By the expression "charging" applied to a battery, he understood charging to its fair capacity for use as a reservoir. He could find no direction in the plaintiff's specification for the use of secondary batteries other than as reservoirs.

Mr. JUSTICE A. L. SMITH: What do you understand by the direction, "in order to keep the electromotive force constant"?

WITNESS: That it was to be the same voltage throughout the mains. There would be resistance in the mains, and by dotting his secondary batteries about the mains the plaintiff would obtain his object better. The defendants did not use their secondary batteries in that way or for that object. They achieved their purpose by feeders and pilot wires.

Cross-examined by the ATTORNEY-GENERAL: By feeder you mean a wire which takes the current away from the engine room, which feeder wire is not tapped by lamps until at a required point?—That describes a feeder.

A pilot wire is simply a tell-tale to tell the people in the engine room whether the voltage has fallen?—It tells what the pressure is at the point where you begin to tap the mains.

Feeders are used on any system which is broken up by subdivisions?—Yes.

During the time the battery is charging and the generator going, will not the amount of current going into the battery depend upon the number of lights that are on in the mains?—It depends upon the position of the switch more than anything else.

Does not the current in your system depend from moment to moment on the lamps which are on?—No; it depends on the construction of the dynamo.

Do not the presence of secondary batteries—the switch remaining constant at any given position—tend to diminish flicker?—I say advisedly they do not at all.

WITNESS went on to say that a description of the defendants' system appeared in the *Engineer* for December 20th, 1890. The *Engineer* said: "One of the advantages found by having more than one pair of batteries attached to the system, at points tolerably wide apart, is, that the effect of the regulating movement of switching in an extra cell, which would show a difference of 2 volts on the lamps, is partly neutralised by the distant battery, consequently, if such a regulation movement is made at Kensington, instead of an alteration of 2 volts for the whole circuit, an alteration of only ½ a volt is perceptible," &c. That was quite correct, and represented what took place.

That could not be done without the presence of secondary batteries coupled up as they are at Kengington?—That means when the dynamos are stopped.

Does not it also apply to when the dynamos are running?—It may do.

With dynamos running and batteries coupled up as they are there described, does not that regulation happen?—I believe it may do so, but I am not certain.

WITNESS then admitted that on April 10th, 1889, he was examined by the Board of Trade, and then gave an answer which meant that in their system they used secondary batteries as regulators to control the electromotive force for long charges. He said further "There is a time when they (meaning the electromotive force and the ampères) balance one another, when the load is neither going in nor out of the battery. After that the load comes out of the battery, that is to say, the dynamos at the stations are supplying all that they can, and they are supplemented then by a certain demand of the battery, and in that way cover the apex on the load. The process is repeated, or reversed rather, on the descending incline; and then comes a point at which we are able to begin putting current back into the batteries, and we continue that until the batteries are full."

Does not that represent exactly the same operation as that described by Lane-Fox?—It does not exactly, but it does nearly; it does not quite, because the batteries are at home instead of distant. We do what Mr. Lane-Fox wished to do, and what he failed to do, by the use of switches and by increasing our batteries, both of which things were impossible at that time.

Mr. JUSTICE A. L. SMITH: It is the use of switches that has enabled you to do what Mr. Lane-Fox could not do?

WITNESS: And the very large surface of our batteries, which was impossible at that time.

Mr. JUSTICE A. L. SMITH: Anything else?

WITNESS: The position of our feeders—at home where they could be controlled instead of in places dotted over the system where they cannot.

WITNESS went on to say that as the potential of the cells fell, the switch was shifted so as to increase the number of cells. The passage in the plaintiff's specification, "So that by increasing the electromotive force during the hours when not much electricity is being used, they" (the secondary batteries) "will be charged," indicated to any electrician that for charging the batteries the pressure of the current should be higher. The operation of regulating was performed at Kensington by a boy observing a voltmeter, and signalling to the man at the engine, according to the rise or fall, to get a rise or fall. This would take 5 or 10 seconds.

The ATTORNEY-GENERAL then read the witness a passage from the "Transactions of the Civil Engineers," in which the witness said: "A comparatively small escape of steam might make the engine-room so obscure, that the men could not see to get to the stop valves for several seconds. Such a trifling derangement, when accumulators were used, was of absolutely no moment; but when accumulators were not employed, it was certain to make a great blink, and probably an extinction of the lights."

WITNESS said he adhered to that.

Now, I ask you this, whether, when the steam escapes, and the steam valves cannot be altered, these accumulators are not here pointed out as acting as regulators?—Not without the switches.

Did not you mean your audience to understand that the accumulators were acting as regulators?—No, I did not. What I meant was well understood.

WITNESS was then exhaustively examined as to his experiments, which he said had been proceeding since the trial began, and just before it began. He had made the same experiments before the trial, and repeated them half-a-dozen times, he should think, in the last 10 years. He kept all his records, and would give them to counsel.

Where in the specification do you find any directions that you are to have only 1 per cent. above the charge?—I did this on Prof. Perry's evidence.

Do you suggest that, with the then knowledge, anybody would think of keeping the E.M.F. as low to charge Planté's batteries at only 1 per cent.?—No, he would not; but in order to keep the E.M.F. constant, we are told to raise it, which is a consideration, to my mind.

With regard to the second experiment, WITNESS said that a cell in good condition, with practically all its charge in it, ought to stand above 2 volts for a considerable time, even after a moderate rate of discharge had taken place. It was a very remarkable fact that after five minutes of discharge in this case the voltage fell to 1·83.

Does not that show that your cell was in a bad condition?—Yes.

Were not you practically trying to charge a nearly full cell with a very great excess of pressure?—Yes.

Has it not been known for years that with the cell nearly full, as you describe, the internal resistance is so enormously increased that you require a very much larger percentage of charging current to get the potential in?—My own experiments show me that is not the case.

With regard to test No. 3, I call your attention to the fact that for five hours the cell maintains the potential which is within the Board of Trade—easily from 1·98 to 1·92. Therefore this cell, or 50 of these cells, would have, for six hours, produced a standard within the limits you have referred to, and if you required to supplement the potential of that, all you would have to do would have been to put on another cell?—That is all; that is quite true.

From the point of view of voltage, was not your cell practically a full cell?—Yes.

This result which you brought to my Lord in order to demonstrate what you suggest is the absurdity of Prof. Perry's theory, commences with a cell practically of full voltage?—Not at its full static voltage.

Mr. JUSTICE A. L. SMITH: Why, if you were going to do this with 101 volts going into the battery, do you take a crammed full battery?—Because I tried it with an empty battery, and it was even worse then, for Mr. Lane-Fox. If the cell was nearly full there was not the same liability to sulphating as if at the lower point.

The ATTORNEY-GENERAL: Switches were perfectly well known in 1880?—Not such switches as are necessary for batteries.

Was not a 3, 4, or 5-way switch in order to switch in or take out one or more additional cells of a primary battery perfectly well known?—I do not know for certain, probably they were.

Did you not sell them yourselves at about 10s. a terminal. Here is your catalogue?—Not for putting in cells; we may have sold multiple switches.

The switch for adding or taking off cells of a primary battery was perfectly well known?—For a primary battery they were. We do not use a single multiple switch. It is a distinct invention, using two switches. To detach the charging switch from the discharging switch was an invention.

Was not the addition or subtraction of extra primary cells to increase the voltage or to diminish the voltage of a primary battery perfectly well known and actually pointed out by Planté in connection with secondary batteries?—I believe it was.

Is there any record of how long the switches stood on any particular day without any change being required?—We never deal with one feeder by itself. There is a tell-tale for each feeder. If there is any necessity for an alteration, it is made on the engine or on the switches.

WITNESS went on to say that it was possible the two other modes of cutting in or out cells were as well known in 1878 as now. For the purposes of the Law Courts they had 99 E.P.S. accumulator cells. The reason those batteries were turned out was because the positive plates went to pieces through not being properly charged. They were practically identical with those they used now, and if treated now as then, would do the same thing. There was no fault in the batteries. He told Mr. Taylor, one of the supervisors of H. M.'s Office of Works, that he was having great trouble with these batteries, and could not make them work. He told Mr. Lane-Fox that the batteries had gone bad, not knowing then that it was their bad way of using them. They all sulphated to pieces, and were taken away as useless. Other plates treated the same would have been in the same condition.

Did you oppose Mr. Lane-Fox's disclaimer, amongst other grounds, on the question of the possible extension of the patent by the meaning of the word "earth"?—Yes, and Prof. Ayrton gave us a report.

Listen: "It is, and has been during the last 20 to 30 years, quite usual to speak of a return cable as an earth or the earth"?—At that time my information was from Mr. Lane-Fox, and I always took his explanation of what he meant. He clearly defined in his lecture what he meant.

You don't suggest the lecture can vary the specification?—No.

Sir HORACE DAVEY: If you are going to use that, will you explain how you are going to use it?

The ATTORNEY-GENERAL: I am only going to use it with reference to the question to which Prof. Ayrton's declaration was directed. It is with reference to Planté's article that Prof. Ayrton's opinion was given.

Is it not the fact that you did not become aware of the directions Planté had given for secondary batteries until 1885?—I do not think so. I read them, possibly, in 1883.

Were you not led to read them in consequence of allegations that you had infringed the E.P.S. batteries?—No. I was led to read them by Mr. Beaumont, with whom I was taking out patents.

Did not you find you had travelled independently the same ground as Planté?—In some points, yes.

The E.P.S. alleged you had infringed their patents?—We challenged them in 1885 or 1886, but they would not take it up.

Did not you allege that they could not succeed against you because you were working on Planté's, and not on their lines?—Yes; that is as regards the details of the batteries.

Re-examined by Sir HORACE DAVEY: He was not aware that directions were given by Planté, or anybody else, which would enable a competent workman, without any direction, to see the necessity for a system of switches such as he had introduced, or of adjusting the current in such a manner as to charge the batteries, and at the same time keep a constant current in the mains. The E.P.S. batteries were successfully used where it was known how to use them. In his paper before the Institution of Civil Engineers in the autumn of 1891, his remarks were directed to accumulators with switches, and they would not be applicable to accumulators without them. When they used their switches, the secondary batteries as used by the defendants acted as regulators; when the switches were not used, the secondary batteries did not so act. He could not reconcile the direction in the plaintiff's patent that the potential was to be raised when the batteries were to be charged with the direction that the electromotive force was to be kept constant; the two things were inconsistent.

Sir HORACE DAVEY said that if his learned friends could suggest any other experiment they thought was required, it should be made in the presence of anybody they liked to name.

This was in answer to a suggestion by the Court that the witness should make out a column in his Table 2, with the batteries at the different potentials at which he took the test.

At this stage the further hearing of the case was adjourned until his Lordship's return from the Old Bailey.

(To be continued.)

John Denby v. Ernest Scott and Mountain.—Some time ago John Denby, stereotyper and electrotyper, 4, Swinton Row, Edinburgh, raised an action in the Court of Session, Edinburgh, against Ernest Scott and Mountain, engineers, Close Works, Newcastle, concluding for payment of £500. The defenders, he said, supplied him with a machine for electrotyping purposes at a price of £55. The machine, he stated, did not work satisfactorily, depositing the copper in granular form, and he claimed damages in respect that the defenders had supplied him with a machine which was constructed for nickel-plating. The defenders contended that the machine which they supplied to the pursuer was capable of doing the work the pursuer intended it for, but he did not fit it up properly nor work it skilfully. Lord Kyllachy, who heard the case in the Outer House, thought there was more probability of something being wrong with the management of the pursuer's bath or the management of the gas engine, than with the dynamo, and he gave judgment in favour of the defenders, with expenses. The pursuer appealed to the Second Division of the Court, which consists of the Lord Justice Clerk and Lords Young, Rutherfurd-Clark, and Trayner. When the appeal came before the Second Division the pursuer lodged the following minute:—Prior to the dynamo in question being furnished by the defenders to the pursuer, it was on its construction being completed, subjected by them to various tests in their works at Newcastle. At this time the defenders had full information as to the driving speed of the pursuers's gas engine, and the result of the test was to show that at a normal driving speed of the gas engine, the dynamo developed a voltage greatly in excess of what is suitable for electrotype purposes, the proper voltage for electrotyping purposes being between 1 and 2 volts. The results of the tests were recorded in the book or books kept by the defenders at their works for the purpose of recording tests of electrical machines manufactured by them. The defenders are called upon to produce the books referred to. The dynamo was thus known by the defenders to be unsuitable for electrotyping, and disconform to contract when it was furnished by them to the pursuer. All these facts were unknown to the pursuer at the date of the proof. They were quite recently communicated to him by George Leonard McAlpine, now resident in Edinburgh, who was in the employment of the defenders at the time when the dynamo was constructed, who took part in its construction, and was also present at the tests and the recording thereof. The existence of George McAlpine was entirely unknown to the pursuer at the date of proof, and was brought to his knowledge by a mutual acquaintance named Mr. Herbert Page, gas engineer, residing in Warrender Park Road, Edinburgh, to whom McAlpine had mentioned in conversation his knowledge of the subject." In respect of this minute the judges ordered further evidence to be led and it was taken on Monday last before Lord Rutherfurd-Clark. George McAlpine gave evidence to the construction of the dynamo, and the tests made at Newcastle, which were recorded. Prof. Walmsley, of the Heriot-Watt College, Edinburgh, said the tests which were made at Goskirk's and Chambers's works with the dynamo were made for a 6-volt machine, and not for a 2-volt machine. He considered the tests made in Newcastle were excessive for the depositing of copper. The tests taken at Goskirk's were also too high for copper plating. In cross-examination, the witness said that at the proper speed, and with the proper amount of work on it, the machine, according to the Newcastle test, was a good electrotyping machine. A machine that did the work produced was a good machine for electrotyping. For the defenders, William Charles Mountain said the dynamo in question was made at the works in Newcastle in the usual way, and the result of the tests was made in the test-book. As the result of the tests, he was perfectly satisfied with the machine. On Saturday last the machine was again tested in Messrs. Chambers's printing office in Edinburgh in the same manner as originally at Newcastle, and produced the same good results.

George Rolf, chief electrical assistant in Messrs. Scott and Mountain's works, said there was no change whatever made in the machine after it was returned to Newcastle by the pursuer. He had seen the machine several times since it was brought back to Edinburgh, and on Saturday he was present when the machine was tested and taken to pieces in Messrs. Chambers's office. The work produced was very satisfactory. Dr. Peddie, assistant professor of Natural Philosophy in Edinburgh University, stated that on Saturday, in Messrs. Chambers's works, the machine was tested according to the conditions of the Newcastle trial. The machine did excellent electro-typing work. W. A. Bryson, electrician, Edinburgh, was held as agreeing with Dr. Peddie. Hugh Mackay, manager of the electrical department in Messrs. Chambers, said the dynamo in question had been in their works since November last, and had not been altered in any way. The machine was tested on Saturday, and gave entire satisfaction. This closed the evidence, which Lord Rutherfurd-Clark will report to the Second Division.

The National Telegraph Works Company, Limited.—In the action of Hedges *v.* the National Telegraph Works Company, Limited, Mr. DRUCE appeared before Mr. Justice North last Friday in support of a motion for the appointment of a receiver of the property of the company. He said that the action was brought by the plaintiff on behalf of himself and all other debenture holders. The plaintiff was the holder of six debentures of £25 each. Since the notice of motion had been given, the company had passed a resolution to wind up voluntarily, and the principal debentures had now become payable. It was asked that Mr. James Rhodes, the gentleman appointed in the voluntary liquidation, might be continued as receiver.

The company did not oppose.

Mr. JUSTICE NORTH appointed Mr. Rhodes as receiver.

THE BEHAVIOUR OF INSULATING MATERIALS UNDER THE ACTION OF HIGH POTENTIAL DIFFERENCES.*

BY H. BLECKLY BOURNE and W. FOX BOURNE.

ELECTRICAL engineers have recently been devoting a great deal of attention to the transmission of energy by small currents at high pressures; and it is clearly advantageous to increase the potential difference until the expense of insulating the apparatus neutralises the saving in copper. The question of insulation is, of course, the main difficulty, for as we increase the P. D. many substances which are ordinarily considered insulators have to be regarded as fairly good conductors. Numerous experiments were shown to illustrate this point, the current being obtained from a "Hedgehog" transformer capable of developing about 25 H.P. at 100,000 volts, which had been lent for the occasion by Messrs. Swinburne & Co.

The question of sparking distance in air does not seem to be of any great practical importance, but as it has recently been referred to, the following figures obtained at Messrs. Swinburne's works, may be of interest:—

SPARKING DISTANCES BETWEEN NEEDLES.

P. D. in Volts.	Sparking distance in inches.
3,000	0·11
14,900	0·5
24,000	1·0
39,000	1·6
50,000	2·2
62,000	2·8
74,000	3·5
92,000	4·5
97,000	5·0

SPARKING DISTANCES BETWEEN PLATES 2½ INCHES DIAMETER.

P.D. in volts.	Sparking distance in inches.
13,000	0·16
20,000	0·40
44,000	1·0
70,000	2·0
90,000	3·0
105,000	4·0

The above results were obtained on a cold, dry, day, but can only be regarded as approximate, as the distance was found to vary a good deal with atmospheric and other conditions, so that concordant results could not always be obtained on different days. By striking an arc between electrodes of tin wire, which gradually melted, a flame of considerable length was exhibited, and it was pointed out that the length to which an arc could be drawn depended very largely on the current strength available.

It was next shown that, for overhead work at very high pressures, even oil insulators of the best design are quite useless. Wires from the transformer were connected to the stalk and groove of an insulator which had been dried and filled with clean resin oil; brush discharges immediately occurred over the surface of the porcelain, and when a P.D. of 60,000 volts was reached a spark jumped from the wire to the stalk. Two wires were placed near the ends of a piece of slate about a yard long, and sparks passed freely from the wires to the slate; and a sort of arc lamp was arranged with slate pencils for electrodes. A similar conducting power was shown to be possessed by vulcanised fibre and asbestos millboard. The discharge does not break down or perforate these substances; they behave exactly like conductors. A curious effect was shown with a long piece of slightly damp wood; numerous small arcs being formed, which finally ignited the wood.

The experiment with the oil insulator, and other experiments shown, point to the fact that surfaces of insulating materials, unless absolutely clean and dry, have considerable conducting power. A discharge may sometimes take place on the surface of a non-conductor across a distance much greater than the striking distance in air, and once a discharge has started an arc is formed. A cable insulated with a layer of rubber a foot thick might be useless for 50 or 100,000 volts, if it had even a small crack. This creeping discharge was also shown by the now familiar experiment in which a pair of discs are separated by a large sheet of glass. In one of the experiments shown, the glass did not break, though the discharge passed through it; and it was found that if there ever had been a perforation, the heat of the arc had fused the glass and entirely sealed up the hole.

The potential difference required to break down or perforate insulators is quite a different matter from the discharge over their surfaces. A number of samples of broken down insulators were exhibited; they were materials which had been tried for use in condensers, and were in the form of thin sheets of mica, celluloid, paper impregnated with various resins and waxes, &c., and were about 6 mils thick; they had been perforated with potential differences varying from 2,000 to 6,000 volts. A piece of cable insulated with a layer of vulcanised rubber of the best quality, rather over ⅛th of an inch thick, was shown; it had withstood 50,000 volts for 25 minutes. In such cases the time element is of great importance, and the dielectric is usually found to become very hot before it breaks down. This fact indicates a very important difference between the effects of direct and alternating currents on insulators. Whenever, as in the case of a concentric cable, the two conductors are at all close together, we have a condenser which is being rapidly charged and discharged. Now in the case of most solid dielectrics there is a good deal of soaking in, and consequent loss of energy, which manifests itself as heat. This was made very evident in the case of a condenser which was tried at Messrs. Swinburne's works. This condenser was made of sheets of tinfoil insulated with paper soaked in paraffin wax in the usual way; its insulation, measured with a steady E.M.F. of 240 volts, was about 6 megohms, and the active surface of plates was 5,000 square inches. When it was connected across a 2,000-volt circuit, it was found to absorb more than a horse-power, so that a considerable rise of temperature was not surprising. But it was also noticed that its capacity rapidly diminished, and finally disappeared, which was, on investigation, found to be owing to the fact that the foil had melted, and so become disconnected from the circuit. Another condenser, made with glass plates $\frac{1}{10}$th inch thick, broke down with 2,000 volts after about five minutes, apparently owing to internal cracks caused by the heat evolved. In the case of the sample of rubber-covered wire above referred to, the compound in which the braiding had been soaked melted in five minutes, and the rubber became quite softened by the heat in about 15 minutes.

This heating effect is much less in the case of most fluid insulators, but seems to be more important in oils having a high specific induction capacity.

Some experiments were then arranged to show some actions of oils under high voltages. A plate was immersed in castor oil, and a point supported a short distance above the surface. On switching on the transformer, a distinct depression was produced on the surface of the liquid. Two plates were then arranged, one over the other, separated by a layer of castor oil on which was floated some paraffin. When the plates had a difference of potential of 20 or 30 thousand volts the castor oil rose in a sort of hill, owing to the fact that its specific inductive capacity is higher than that of paraffin, so that by its movement the capacity of the arrangement is increased. It was also shown that particles of sawdust in resin oil were formed into chains, producing a discharge across a considerable distance.

The experiments were concluded by sending the current from the transformer through a number of vacuum tubes. These were, of course, brilliantly illuminated, but the current was not maintained for more than a few seconds, as an intense heating of the glass and electrodes ensues, which usually break the tubes. This fact renders it difficult to measure the power absorbed, but it was estimated from the primary current and voltage that a comparatively small tube may easily be made to absorb about 2·5 H.P. while giving a light of only a few candle-power.

In the above described experiments the potential differences were measured by a direct reading electrometer kindly lent by Messrs. Swinburne & Co. This and the transformer are intended to be used for experiments to be shown by that firm at the Crystal Palace Exhibition.

* Abstract of paper read on March 11th, before the Old Students Association of the City and Guilds of London Institute, at the Central Institution, South Kensington.

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

Abstract of Discussion, March 10th.

MR. R. H. HOUSMAN referred to some curves in Mr. Siemens's paper showing that the loss by hysteresis increased with the number of ~ per second. These curves were, he pointed out, the loss by hysteresis *per second* and not per cycle, if the latter value were plotted it would be found that the loss per cycle decreased very materially with increase

of ~. This he confirmed by experiments of his own with low frequencies, varying from 3 to 30 ~ per second.

Mr. RUSSELL had tried many experiments to see if a spark micrometer could be relied on as a rough voltmeter for an induction coil spark, and had come to the conclusion that it was quite unreliable, the results varying five to ten per cent., even when the greatest care was taken to polish the electrodes. He also showed some curves of sparking distances between balls, spears and points. Unlike Mr. Siemens he had found a very great difference with differently shaped electrodes. The sparking distance being at 2,000 volts, three times as great between two spears as between a spear and a ball, and the ratio increased as the volts were raised. In no case did he get so short a distance as Mr. Siemens. He had found that time had a very distinct effect on sparking distance. An E.M.F. which would not cause a spark at once, would often do so if left on for one or two minutes. He objected to the expression of sparking distance in volts per millimetre. All the curves of sparking distance with various volts were convex (to the axis along which E.M.F. was taken), *i.e.*, the volts per millimetre decreased, as the volts themselves rose in some of the curves to as much as 25 per cent.

Mr. ESSON suggested that it would be well in the cable transformer to bring the two ends together and get a closed iron circuit. He also showed some curves giving the all day efficiency of two transformers, the one with the copper loss three times that in the iron, and the other with the iron loss three times that in the copper. The all-day efficiency of the latter appeared to be nearly twice as great as that in the former, both curves were based on the average load curve of the Kensington Court Station.

Mr. SIEMENS in reply said that Prof. Perry had thrown some doubt on the temperature determinations because they depended on the measurement of $\cdot 002^{\omega}$ in $\cdot 7^{\omega}$. He could assure him that there was no difficulty in making such a measurement to that degree of accuracy, and that it was done every day in practice. Mr. Evershed had also doubted the accuracy of the method; but he (the speaker) would point out that it was a very well known and tested one, being in fact nothing but that of the electrical thermometer of the late Sir W. Siemens. In reply to Mr. Russell he could only say that he found that when the electrodes were carefully polished, *his* results *did* agree within 1 per cent., and that he had found that time had no influence whatever on sparking distance. He did not think that closing the iron circuit in the cable transformer would be of any appreciable advantage; the induction was a little less just at the ends than elsewhere, but not enough to trouble about.

NEW PATENTS—1892.

3,559. "Improvements in the manufacture of compositions for insulating or other purposes." S. W. KIMBLE. Dated February 23rd.

3,560. "Improvements in trolley-wire hangers and other appliances for use in overhead electric railway systems." S. W. KIMBLE. Dated February 23rd.

3,561. "Improvements in trolley wheels for electrically propelled vehicles." S. W. KIMBLE. Dated February 23rd.

3,562. "Improvements in the construction and mounting of electrical connecting devices upon their non-conducting supports." S. W. KIMBLE. Dated February 23rd.

3,569. "Improvements in the glass chimneys, globes, and shades of electric and other lamps." A CAY, trading as J. STEVENS & SON and also as STONE, FAWDRY & STONE. Dated February 23rd.

3,572. "Improvements in apparatus for electrically operating or controlling type-writing machines, type-setting machines, or apparatus for recording, indicating, or signalling." A. F. LAW. (Communicated by E. F. Law, Russia.) Dated February 23rd.

3,595. "Improvements in shades and reflectors for incandescent electric lamps." F. MOORE. Dated February 24th.

3,654. "Improvements in electric burglar alarms." E. RICHTER. Dated February 25th. *(Complete.)*

3,662. "An improved method of electric traction. Underground system." W. R. C. WAKLEY. Dated February 25th.

3,707. "Improvements in electric arc lamps." J. C. MEWBURN. (Communicated by P. Sée, France.) Dated February 25th.

3,719. "Improvements in apparatus or switches for controlling electric currents." A. B. BURNAND. Dated February 25th.

3,724. "An improved electric arc lamp." H. W. SANDER and M. D. MEMMELL. Dated February 25th.

3,750. "Improvements in microphones and in apparatus connected therewith." Sir C. S. FORBES. Dated February 26th.

3,758. "Improved holder for incandescent electric lamps." W. F. PARKINSON. Dated February 26th.

3,801. "Improvements in electric bells." L. W. WINNALL and W. H. WINNALL. Dated February 26th.

3,869. "An improved electrical push-button for signalling circuits." J. M. ELLIOTT. Dated February 27th.

3,873. "Improved insulating media for electrical conductors." H. C. DONOVAN. Dated February 27th.

3,875. "Improvements in and relating to electric motors." C. COERPER. Dated February 27th. *(Complete.)*

3,881. "Improvements in electrical accumulators." K. KAHABKA. Dated February 27th.

3,887. "A system of sending and receiving signals on telephone lines for use in fire brigades and other purposes." F. E. STUART. Dated February 29th.

CORRESPONDENCE.

Electrically Controlled Organs.

My brother instructs me to send you enclosed copy of a letter I have just written on his behalf to the editor of the American paper *Electricity*.

F. Hope-Jones.

[COPY.]

Birkenhead, *9th March.*

The Editor, *Electricity*, of New York and Chicago.

Dear Sir,—I was much interested in reading the account of the Gracechurch electric organ appearing in your issue of February 17th in which you quote part of a lecture I recently gave, as printed in the London ELECTRICAL REVIEW of January 15th. The "second touch" and the "Sforzando pedal" are, however, only two details of the "Hope-Jones System of Electrical Organ Control," and I shall feel obliged if you will correct the impression which the public are likely to form on reading your page 51. All the other inventions there mentioned are part of my new electric system, as described in the printed matter enclosed herewith, and are not the work of the builder of the Gracechurch instrument. You may be interested to hear that since the inventions were introduced in this country (twelve months ago) no less than 23 London and Provincial firms have been licensed to work under my patents.

I shall shortly be making arrangements for the introduction of the invention into the United States, and shall then be happy to give you more information on the subject.

I am, Dear Sir, yours faithfully,

(Signed) ROBT. HOPE-JONES.

Transmission from Niagara to Chicago at One Million Volts.

The recent agitation accruing from the Frankfort-Lauffen transmission experiment, has probably reached London, as it has the shores of this recreant Columbia, and herein notably Chicago, mainly in anticipation of some of the energies of Niagara, at the great World's Exposition.

It may, therefore, be interesting to readers to have particulars of one at least of the crop of schemes that have been induced thereby, and that is likely to materialise.

The writer has figured before in these pages, once! a year and more ago, when I felt much betrodden by the wisdom of the Editor likening my pet dynamo to an oven wherein wires were baked. The machine was built, however, in a small Midland town of England, so much more could not be expected, not because of England, but because Englishmen at home are generally pessimists and not proud enough. "The machine will be built again with a ventilating fan inside." The inventor then made another visit to Uncle Sam. Returning to Niagara, it has been my experience to design a large number of high potential dynamos, notably, some extremely efficient 2,500 volt generators. These machines have proved very satisfactory, as run in series, so much so, that I have proposed to operate a large number in series, thus obtaining voltage sufficient to carry a current with inappreciable loss an unlimited distance. I have ventured 1,000,000 volts before the Chicago Electric Club, but have since come down to 50,000, with bare overhead wires, though I believe that 1,000,000 may be carried with absolute safety through an oil insulated cable, somewhat similar to the Brooks underground conduit. I have made some experiments on this with a Holtz machine.

In a communication to the New York *Electrical Engineer*, of January 20th, I have given some figures on 1,000,000 volts.

The generators would consist of series dynamos, with automatic regulator attached to each machine, or all the fields in one circuit, and controlled by an automatically adjustable rheostat. The motors, ordinary series machines, each with a regulator for constant speed, operated by a centrifugal governor and relay.

A pioneer series system of this character is already in operation, I observe, at Genoa, due to M. Thury; and constant current dynamos have been run in series on arc and motor circuits constantly for years, the time therefore seems to have arrived when the original high tension arc current will prove the solution of the great question of the distribution of electricity and of Niagara.

George Edensor Dorman.

Chicago, *March 1st*, 1892.

CRYSTAL PALACE ELECTRICAL EXHIBITION, 1892.

Cook, Smythe & Payne's Patent Fireproof Conductors and Fittings.

The conductors in this system are composed of tubes of copper, or other suitable metal, arranged usually on the concentric principle.

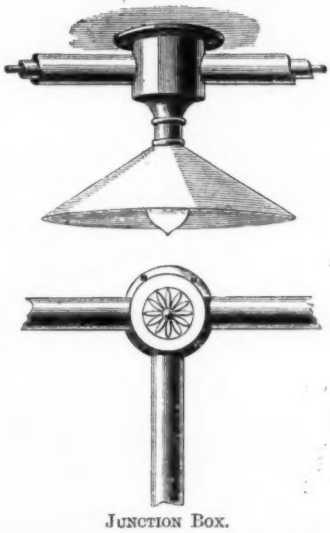
An inner tube or rod forms the lead or positive conductor, a second tube outside this forms the negative or return for the current, and a third outer tube is usually employed as a mechanical protection, carrying no current.

The system may be seen working at Messrs. Smythe and Payne's offices, Albany Buildings, 39, Victoria Street, Westminster, and also at the Crystal Palace Electrical Exhibition, where they have fitted up these conductors in the French Mediæval Court for Messrs. Benham & Froud's installation of fittings, &c., for church lighting. The court has been arranged to represent the interior of a church. This was illustrated in our issue of February 5th.

Two tubes lead up the wall from the switchboard, forming two circuits: one passes over the altar, and supplies current to a 12-light corona, continuing along the ceiling and down the opposite wall to a large brass 9-light standard. The second circuit supplies two wrought iron electroliers hung in front between the arches.

The tubes are left bare, air insulation being employed in combination with rings or studs of insulating material

Mode of Fixing Lamps.



Junction Box.

(earthenware, slate, &c.), placed along the tubes at intervals to prevent the tubes from touching one another.

A large number of junction supports, or junction boxes, have been designed to support the tubes where there are joints, branches, &c., and to work in combination with the usual fittings in everyday use.

Only this one kind of insulation is employed, and the insulation resistance is said to be very high. As the ring separators are usually serrated, notched, or hexagonal, there is room for free circulation of air, and any water entering by accident can easily escape.

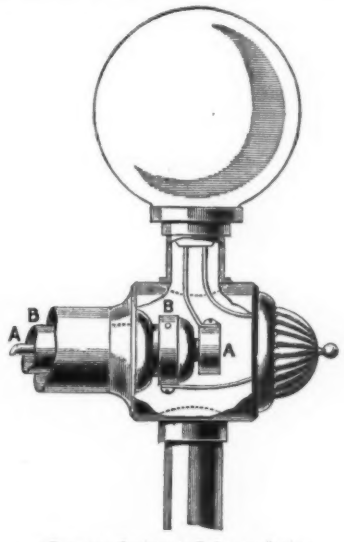
In a damp situation, or if the tubes become wet inside, they can be heated either externally or by drawing hot air through them, or a large current can be passed through one of the conductors so as to make it hot, and thus drive off moisture. This cannot be resorted to with any ordinary wires without great risk of melting, if not destroying, the insulation.

The tubes are put together in segments and erected together, the joints in the junction supports being made in a variety of ways, according to the requirements of the case.

They may also be soldered, brazed, or even welded together electrically.

Connections for small branches may be made by soldering pieces of strip or ordinary wires round the ends of the tubes, and connecting these together or leading them into the fittings.

Joints are also made by means of screwed sleeves, T and L-pieces, similar to gas or water pipes. This method is employed where air-tight and water-tight joints are required.



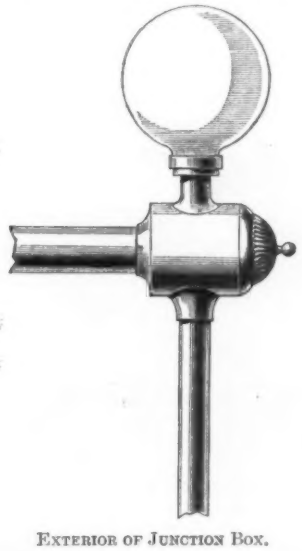
A, Inner conductor; B, Outer conductor

Junction Box.—Showing Interior Arrangement.

Also by means of flanges or metal rings, screwed or soldered to the ends of the tubes, and connections are made from one tube to the other by means of wires or strips screwed to the edges of the flanges.

One of the chief objects of the invention is to provide a conductor that will, as far as possible, do away with the risks of fire caused by over-heating of the conductors or by leakage.

By employing fire-proof materials throughout, by using no wood casing, and by suspending or fixing the tubes away from the ceiling or walls, fire is almost impossible.



Exterior of Junction Box.

The conductors must become heated, and remain so for a considerable time, before the outside protecting tube and the supports would become hot enough to set fire to the ceilings, walls, &c., to which they were fixed.

The mechanical nature of the system is at once obvious. A large amount of work in connection with the fittings and

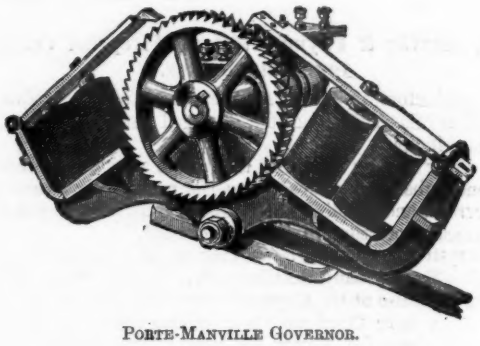
conductors can be done in the workshop, and thus the time required for erection is decreased, and less inconvenience is caused to the occupants of the building where the tubes are being erected. Less joinery and carpentry are required, and the expense and necessity of repainting and decorating is avoided.

A special arrangement has been designed for the mains in a large building, divided up into offices or flats, where the current is increased as consumers have their flats or offices fitted up for the electric light. The tubes are erected in sections from floor to ceiling, and if the capacity of any section of the tubes is not sufficient to carry the current demanded, the section can be removed, the copper conductors can be drawn out, and tubes of larger capacity inserted in the outside protecting tube, the sections being then replaced and connected up.

The tubes can be suspended along ceilings or on walls—like picture rods, or laid along the tops of the cases in museums or libraries.

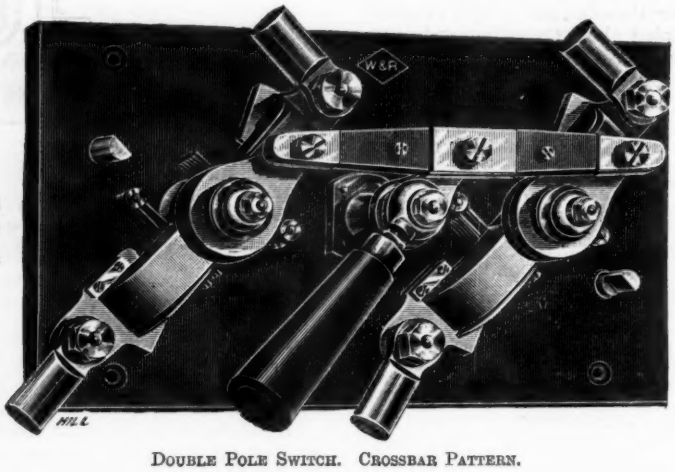
They can be placed under the counter, and connected with standards in banks, &c., or run from one standard to another above the counter, and articles of all kinds thrown over or hung from them.

trated will be found very convenient. Many other types are made, and the company are in a position to fulfil any reasonable requirement in this special field.



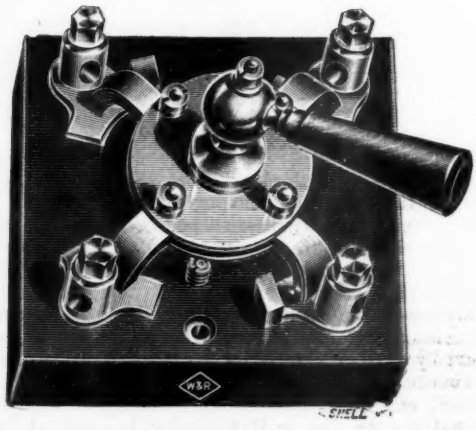
Porte-Manville Governor.

The company are introducing several new forms of instruments, a set of which we illustrate. To meet the demand for a reliable electrical governor, for controlling turbines and engines driving dynamos, a special form of the Porte-Manville type has been designed. The variations in the strength of an electric current are made to actuate a ratchet wheel and so control the movements either of the connecting rod between the mechanical governor and the steam engine, the valves of a turbine, or a switch which varies the resistance in circuit in the exciting circuit of a dynamo.



Double Pole Switch. Crossbar Pattern.

High Tension Double Pole Switch. Quick on—quick off.



Double Pole Switch. New Type.

Messrs. Woodhouse and Rawson show various types of switches suitable for carrying large currents up to 1,000 amps.

Double pole switches have lately come into use, and several special designs of these are shown.

This type is suited for installations when very large currents are used; our illustration shows a later design, which, for smaller currents, is rapidly coming into favour.

Where high electrical pressures are used, the switch illus-